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PLAYA WETLANDS AND WILDLIFE ON THE SOUTHERN GREAT PLAINS: A CHARACTERIZATION OF HABITAT

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A related publication on playa wetlands is also available from the U.S. Fish and Wildlife Service:

Playa wetlands and wildlife on the Southern Great Plains: A guide to habitat management. FWS/OBS-83/29.

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PLAYA WETLANDS AND WILDLIFE ON THE SOUTHERN GREAT PLAINS:
A Characterization of Habitat

by

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Dr. Fred S. Guthery, Department of Range and Wildlife Management, Texas Tech University (Lubbock), was the principal advisor to the study team. Lori Hight of Nelson and Associates in Boulder, Colorado, developed or adapted the maps and other illustrations; Esther Goodyear provided the word processing service; and Patrice Braverman composed the report.

EXECUTIVE SUMMARY

The Southern Great Plains playa wetland region encompasses the Llano Estacado (Southern High Plains) of the Texas Panhandle and adjacent eastern New Mexico, and extends north of the Canadian River through the Oklahoma Panhandle into southwest Kansas and southeast Colorado. For study purposes, the region is partitioned into five zones having distinct land use, hydrologic, and soil characteristics. Because high-value playa wildlife habitat concentrates in one zone (Irrigated Cropland) near the center of the study region, most wildlife studies from which the habitat characterization is drawn will pertain to this zone. Every effort is made to show the environmental differences in other zones so varying habitat values may be inferred.

Although playa habitat is well known for its importance to migratory waterfowl in the Central Flyway, its value to resident wildlife is even more pronounced since wetlands are so scarce in this dry farmland region. The characterization incorporates recent research findings in a synthesis of knowledge about the habitat values of playa wetlands.

PLAYA REGIONAL GEOGRAPHY

Playas are either ephemeral or permanent lakes or wetlands, depending on the water depth and persistence, and on the presence of aquatic vegetation. Under the National Wetland Classification System, all playas are classified as palustrine or lacustrine wetlands. A variety of theories have been advanced to explain the origin of playas. There are approximately 25,000 playas within the 68,500-mi^2 (177,400-km^2) Southern Great Plains playa region, with an average surface density generally under 20 ac/mi^2 (about 3 ha/km^2 or 3% of land surface). The majority of playa basins are under 10 ac (4 ha), but they range as high as 600 ac (240 ha) covering the area of wetland soils. During a wet season, the average *water* surface density may be as high as 4 ac/mi^2 (2/3 ha/km^2) in the Irrigated Cropland Zone, but less than 0.2 ac/mi^2 (0.03 ha/km^2) in a dry season.

The semiarid regional climate varies from dry steppe to warm temperate, with annual precipitation averaging 15-22 in (38-56 cm), and mean annual evaporation of about 100 in (254 cm). The main geologic feature is the Ogallala Aquifer which supplies irrigation water often collected in playas, enhancing aquatic habitat, particularly in the west-central Texas Panhandle. Soils range from fine sand to silty clay loam, the latter associated with larger, shallower playas. Most of the study region is smooth plains and shortgrass prairie with production of grains, cotton, cattle, oil and gas as the primary land uses.

PLAYA BASIN ENVIRONMENT

The physical environment of playas is characterized by distinctive soil-water relationships. Soils are generally clays that form a highly impermeable seal, thereby increasing playa water-holding capacity. This feature promotes their use and modification for collection and recycling of irrigation tailwater, while also enhancing scarce wetland wildlife habitat. Soil texture and percolation vary significantly north and south through the playa region; water retention is maximum in the fine-texture area of the west-central Texas Panhandle. This area also has a higher average playa surface density, and irrigated farmland concentrates here.

Water ordinarily accumulates in unmodified playas during late spring and gradually subsides through the summer. Playas modified to store and reuse irrigation tailwater will sustain a larger water surface or volume over a longer period. Most water contained in unmodified playas and not used in irrigation is lost by evaporation before winter. Water quality in unmodified freshwater playas is generally uniform and suitable for irrigation as well as fish and wildlife habitats; saline playas have limited value.

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ECOLOGY OF PLAYA BASINS

Variables affecting the value of playa wildlife habitat may include watershed size and the water surface area and depth; type, height, density, and interspersion of vegetation, and the extent of emergent vegetation; land use, particularly grazing and cultivation; and the extent of modification, particularly excavation and diking. There is considerable variation in annual precipitation and runoff and, therefore, in habitat values, especially for wildlife populations linked with the aquatic environment. Larger playas that collect irrigation tailwater and are not cultivated or heavily grazed appear to provide the best wildlife cover—vegetation that is tall, dense, diverse, and persistent. Those playas modified to concencentrate water can sustain more open water and emergent vegetation during dry years.

Cropland playas containing fresh open water provide valuable waterfowl loafing, roosting, watering, and foraging sites adjacent to grain fields used for feeding. Even without open water, playa wetlands provide important winter cover for upland game birds, raptors, and passerines. Playas offer valuable nesting cover for pheasant and some species of ducks. Coyotes, raccoons, rabbits, ground squirrels, and mice are among the abundant mammals at playa basins. Salamanders and frogs as well as snakes, lizards and turtles are found among the indigenous amphibians and reptiles; most fish populations are introduced. Invertebrates important in the food chain include grasshoppers, fairy shrimp, and snails. Playa habitats also may promote a number of diseases in wildlife—encephalitis, avian cholera, botulism, and duck schistosomiasis.

PLAYA USES AND MODIFICATIONS

The impoundment of natural runoff in playa basins during a wet year may reach the equivalent of all groundwater pumped annually from the Ogallala Aquifer in the Southern Great Plains. However, the accumulation of runoff, particularly in a dry year, may not coincide with optimum irrigation scheduling; stored water may evaporate and seep from playas before it is needed. Therefore, the practical use of playa water for irrigation would require basin modifications such as excavation and diking to concentrate water storage and reduce evaporation. Many irrigated cropland playas, particularly the larger ones, also receive irrigation runoff (tailwater) which is recycled; most of these basins have been altered to reduce evaporation. However, current efforts at water conservation, such as conversion to low-pressure aerial spraying, are expected to greatly reduce tailwater.

Many farmers plant crops into the margins of playas or, in smaller basins less subject to flooding and crop failure, cultivate the entire playa. Year-round grazing at rangeland playas is widespread; many larger cropland playas are grazed between harvest and planting. Numerous playa basins are modified to concentrate water for livestock use. Some playas are used for disposal of feedlot waste, but recycling of untreated feedlot runoff for irrigation could lead to groundwater pollution. Disposal of oil field brine in playas can contaminate surface and groundwater with salt, hydrocarbons, and other accumulations.

Hunting for pheasants, ducks, geese and cranes is the main recreational use of playas. Pheasants congregate at cropland playas during winter when cover is scarce. Large playas with abundant, shallow open water are more likely to be used by geese and cranes, as well as pintails and wigeons; many ducks such as mallard and green-winged teal are more attracted to smaller playas with dense emergent vegetation. There is some use of playa lakes as sport fisheries.

IMPACTS ON PLAYA WILDLIFE HABITAT

There are losses and gains among various playa lake and wetland wildlife communities of the Southern Great Plains as a result of agriculture and other human activities. Adverse impacts linked with crop production focus on reduced habitat diversity or carrying capacity in playas disturbed by the cultivation of crops and burning of weeds; basin modifications to store irrigation tailwater, which reduces the highly productive littoral zone and concentrates waterfowl during dry periods, increasing the disease potential; and the application of chemicals for mosquito and weed control, increasing the potential for wildlife toxicity. Offsetting benefits include the availability of waste grain from irrigated row crops as a wildlife food source, increased density and diversity of wildlife cover from reception of irrigation tailwater in undisturbed playa basins; and preservation of some aquatic habitat during drought because of basin modifications to concentrate stored natural runoff and tailwater.

Impacts from livestock production stem from overgrazing of playas and potential pollution from feedlot runoff. On the other hand, managed grazing can benefit wildlife cover and food supplies, and collected feedlot runoff can help sustain aquatic habitat. Although basin modifications to concentrate water storage may aggravate avian cholera, other diseases are better controlled where shallow aquatic area is reduced by excavation and diking.

On balance, present agricultural practices, especially the collection of tailwater in undisturbed playas, may produce more benefits than liabilities for wildlife in the Southern Great Plains. However, the projected trends for curtailment of groundwater supplies and irrigated crop production indicate greatly reduced tailwater input to playas and, ultimately, reversion to dry land farming with adverse effects on wildlife dependent on a wetland environment. The importation of irrigation water from outside the region, as proposed in recent years, could ameliorate this future impact.

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1.0 INTRODUCTION TO PLAYA CHARACTERIZATION

The Southern Great Plains playa wildlife study region is defined to cover parts of five states where playa lakes and wetlands are common features in the landscape. Playas are certainly important to migratory waterfowl in the Central Flyway; they are *critically* important to resident wildlife in this dry farmland region where any moist or aquatic habitat is exceedingly scarce. The main purpose of characterizing playa habitat is to portray current knowledge as a basis for new efforts at habitat preservation and management of playas for multiple use, including wildlife management.

1.1 DEFINITION OF THE STUDY REGION

Playa lakes and wetlands in the southern region of the Great Plains occur predominately within 43 counties comprising most of north-central Texas, four counties across the eastern New Mexico border, the southeasternmost Colorado county, eight counties of southwestern Kansas, and four counties of Oklahoma, including the Panhandle. The study region overlies the Ogallala Aquifer and is defined by its characteristic landform (flat or smooth plains) and natural vegetation (mostly shortgrass prairie). It should be observed that the Southern *High* Plains, also known as the Llano Estacado, occupies the southern two-thirds of the Southern *Great* Plains, lying south of the Canadian River Breaks (Figure 1-1). Many previous playa studies have been confined to the Llano Estacado, thereby excluding the playa country in Oklahoma, Kansas, and Colorado.

The distribution of playas by size and density of playa basins among the 60 counties of the study region, as well as the sub-regional characteristics of these basins, closely corresponds with sub-regional distinctions in geology, topography, soils, hydrology, and vegetation. For instance, the smaller, deeper playa basins concentrate where medium-textured sandy loam soils and nonirrigated cotton croplands predominate, whereas the larger, shallower basins are concentrated where fine-textured silty clay loams and irrigated corn croplands predominate.

To assist the interpretation and comparison of playa habitat characteristics as related to the differences in playa environments, the study region was partitioned into *five zones*: North Cropland, North Rangeland, South Rangeland, South Cropland, and the Irrigated Cropland Zone which overlaps the middle section of the South Cropland Zone (Figure 1-2).

Playa Lake and Wetland Data Sources. It must be pointed out emphatically that most of the *wildlife* studies supporting this habitat characterization have been conducted in or near Castro County, Texas, at the middle of the Irrigated Cropland Zone. It is in this zone that six counties (Castro, Deaf Smith, Floyd, Hale, Lubbock, and Parmer) have an abnormally high proportion (>30%) of playas providing good to excellent wildlife habitat, particularly because of irrigation tailwater collected in playas here (Guthery and Bryant, in press). There is substantial danger in extrapolating these findings to other zones where they are unwarranted. The more definitive sources of data available for this characterization focus on the U.S. Bureau of Reclamation for water resource information and on Texas Tech University, the U.S. Forest Service, and U.S. Fish and Wildlife Service for wildlife information.

The unpublished data from the 1982 Playa Inventory by the Engineering and Research Center of the Bureau of Reclamation (Denver) were released for use in this study. Based on photointerpretation of LANDSAT imagery, these data reveal for the first time the distribution of playa *water* surface rather than *basin* surface. The Bureau's Southwest Region in Amarillo has also sponsored playa wildlife assessments by faculty of the Department of Range and Wildlife Management at Texas Tech University (Lubbock),

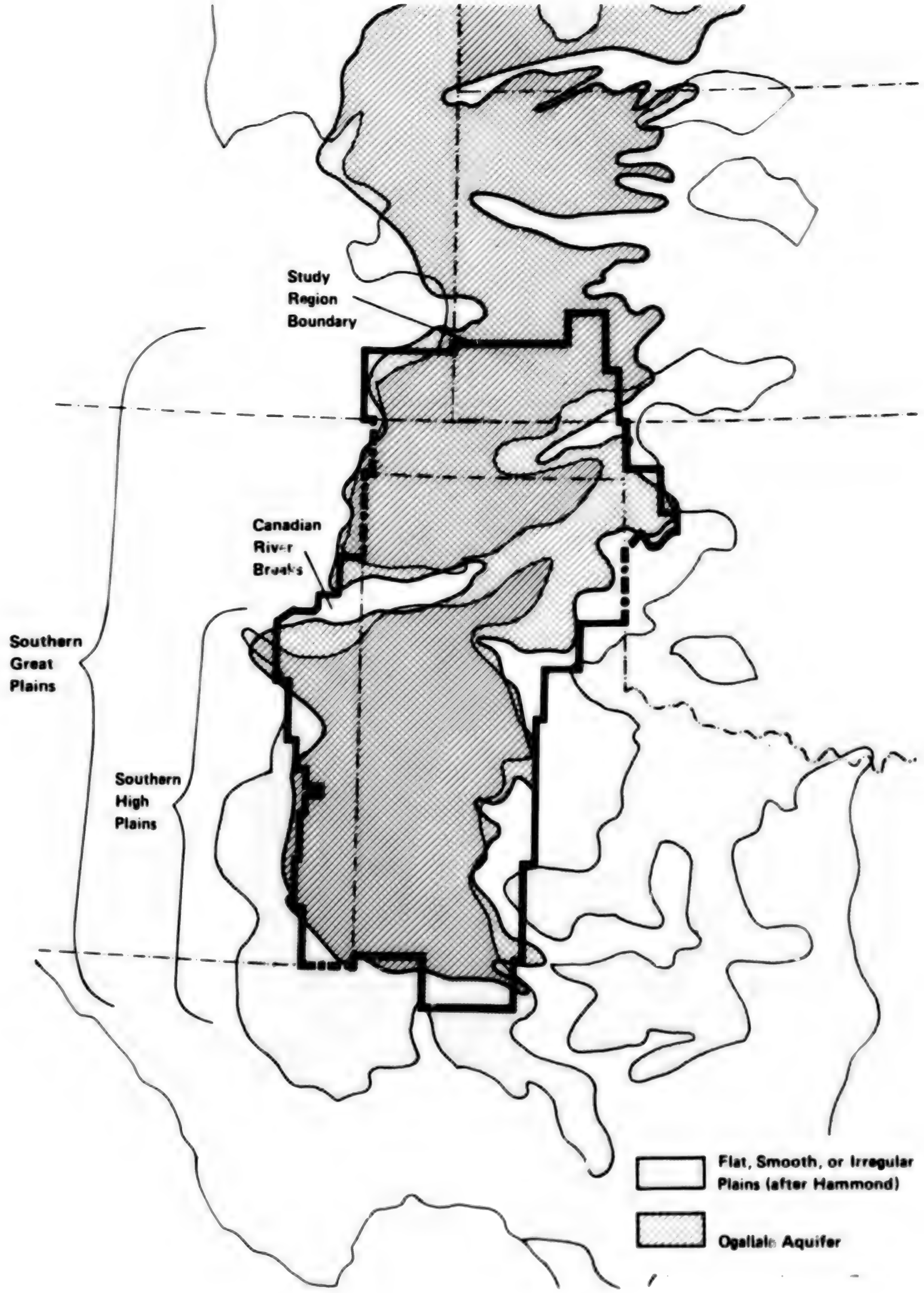

Figure 1-1. Orientation of the study region to the southern region of the Great Plains, the Southern High Plains (Llano Estacado), and the Ogallala Aquifer (Nelson and Associates, Inc. 1982).

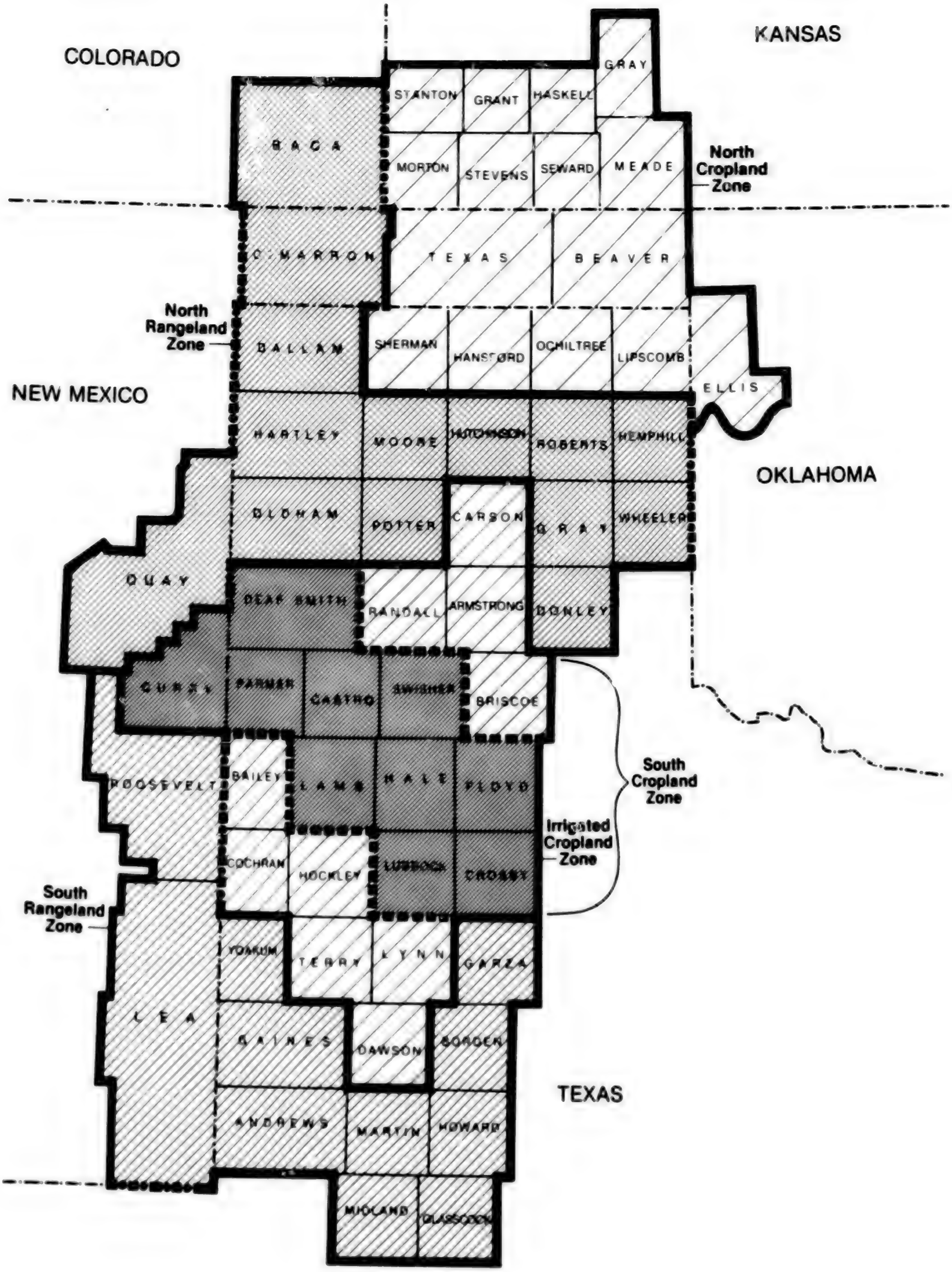

Figure 1-2. The playa lake and wetland study region and zones of the Southern Great Plains (Nelson and Associates, Inc. 1982).

notably Guthery et al. (1981) and Simpson and Bolen (1981).

The Forest Service, through the Rocky Mountain Forest and Range Experiment Station at Texas Tech University, has sponsored other recent work providing important data for this study, particularly dealing with playa wildlife habitat characteristics (Guthery, Pates, and Stormer 1982 ; Guthery 1980).

The Fish and Wildlife Service contributions of data are contained primarily in the characterization study by the Ecological Services Office in Ft. Worth (Curtis and Beierman 1980). Ecological Services in Tulsa provided data from the Six-State High Plains-Ogallala Aquifer Regional Study (Brabander 1981); so has the U.S. Economic Development Administration (Banks, Feeley and Banning 1981). Important earlier data on water availability in Texas High Plains playas (Dvoracek and Black 1973) and on playa use and modification (Schwiesow 1965) resulted from work sponsored by the Texas Water Development Board.

1.2 IMPORTANCE OF PLAYAS TO WILDLIFE

The Southern Great Plains playa lake and wetland region, next to the Gulf Coast, is the most important sector of the Central Flyway for wintering waterfowl. About 90% of overwintering waterfowl in the Texas Panhandle inhabit playa basins (Figure 1-3). In the heart of the playa region—Castro County, Texas, in the center of the Irrigated Cropland Zone—20 migratory waterfowl species occupy playa basins. The habitat features so valuable to migratory waterfowl are both natural and artificial. The natural seasonal flooding and vegetative zonation of playa basins sustain the necessary open water and diverse natural cover and food supplies, while surrounding croplands contribute grain food and, where irrigated, the additional water supply from irrigation runoff.

Many playas in the semiarid, intensively cultivated Southern Great Plains serve as oases of aquatic or semiaquatic habitat (Figure 1-4). Availability of drinking water and dense cover in some playa basins attracts a variety of wildlife other than migratory waterfowl, including shore and wading birds, upland game birds, passerines, raptors, mammalian predators, lagomorphs, rodents, reptiles, and amphibians. Guthery and Bryant (1982) partitioned and classified the general value of wildlife habitat in the Southern Great Plains, based primarily on the amount and permanence of natural vegetation and standing water. The average proportion of playas with good to excellent habitat ranged from 3.3 to 28.6%, with the higher proportions concentrating in the Irrigated Cropland Zone (Figure 1-5). Playas classified as good to excellent would provide overwintering and nesting cover for ring-necked pheasants, year-round cover for small mammals and furbearers, and resting and brooding cover for waterfowl.

1.3 PURPOSES OF HABITAT CHARACTERIZATION

One important purpose behind this characterization of Southern Great Plains playa habitats is to integrate and synopsize the substantial new knowledge about playas with the findings of previous research. In addition to the recent applied research sponsored by the U.S. Departments of the Interior, Agriculture and Commerce, two major symposia sponsored by the Fish and Wildlife Service (Barclay and White 1981) and Texas Tech University (Reeves 1972) have produced a range of findings and opinion requiring some synthesis to be made more accessible and placed in an overall perspective. The other purpose of the characterization is to assemble the knowledge necessary to guide a better informed approach to the management of playa wildlife habitats and populations to balance the interests of wildlife conservationists, hunters, farmers and ranchers, and some municipal and industrial interests.

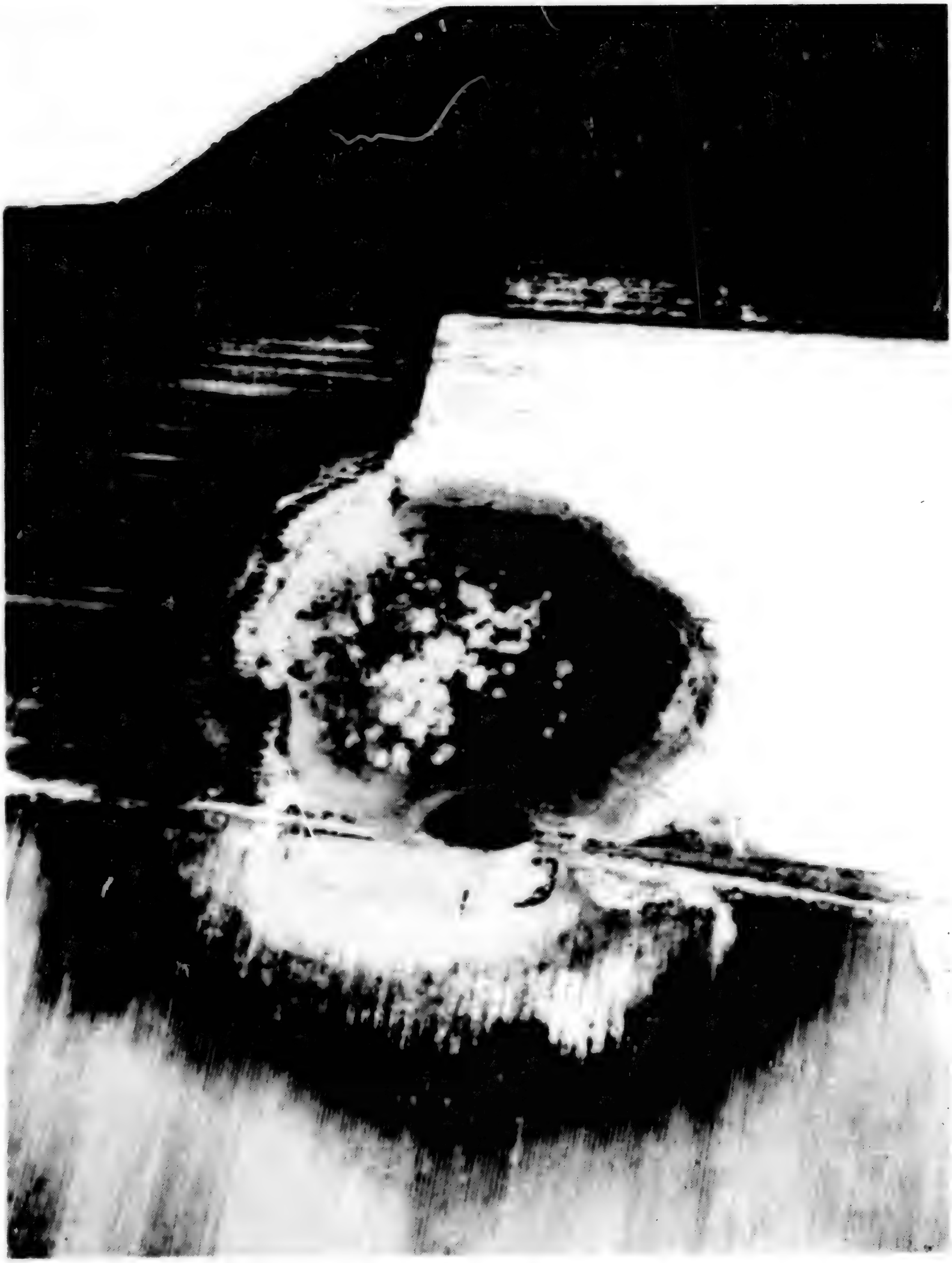

Figure 1-3. Infrared, low-altitude aerial photograph of an unmodified Southern Great Plains playa basin, supporting hundreds of ducks and other waterfowl with diverse natural vegetative cover. Open water is supplemented by runoff of irrigation flows; surrounding grain crops supplement natural food supplies (Texas Tech University, Department of Range and Wildlife Management 1981).

Figure 1-4. Example of a Southern Great Plains playa basin providing a natural habitat "oasis" for wildlife in a semiarid agricultural region that is otherwise habitat-poor, especially lacking lake and wetland environments (Nelson and Associates, Inc. 1981).

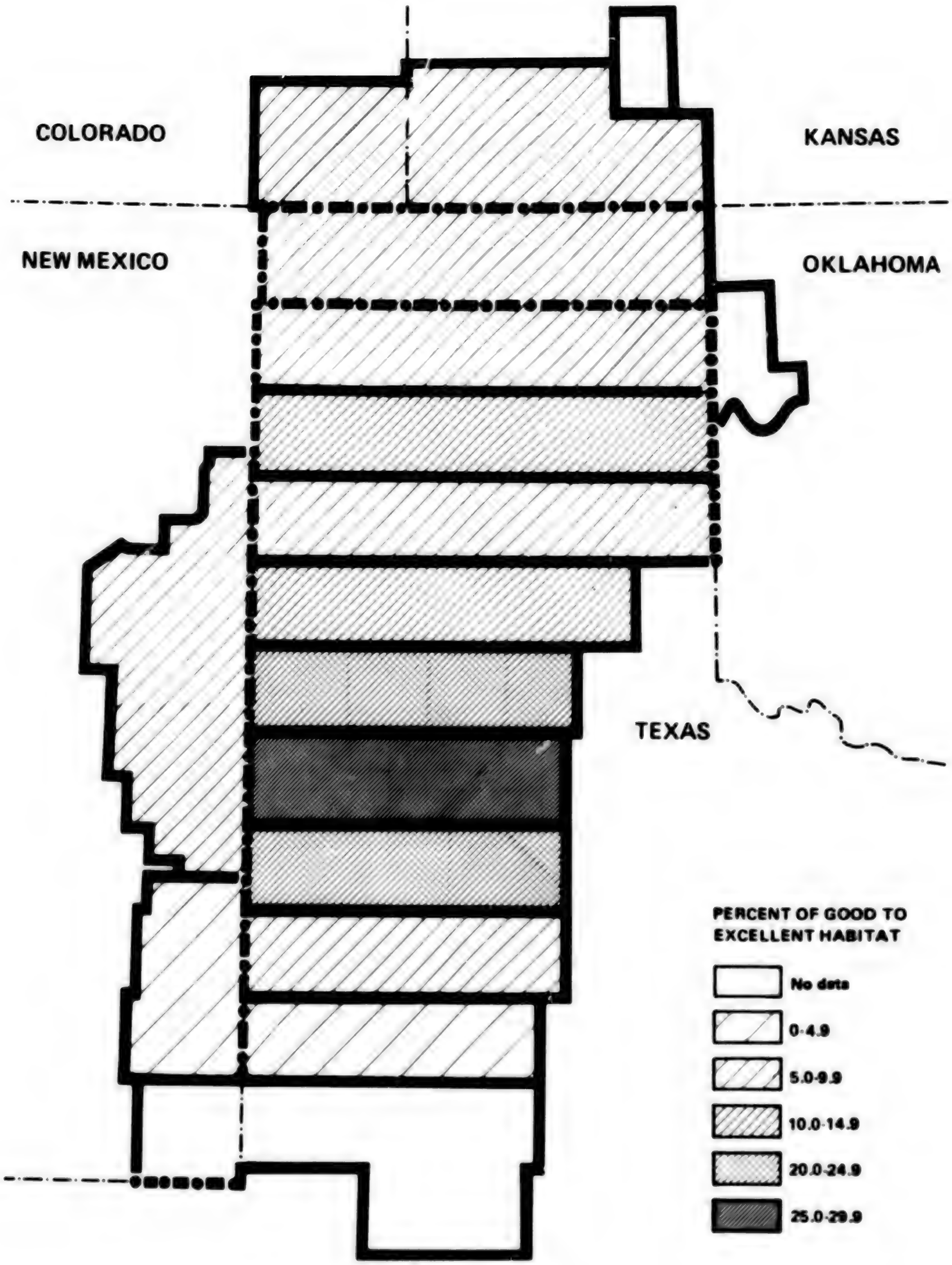

Figure 1-5. Proportion of playas classified good to excellent as wildlife habitat in 12 geographic strata of the Southern Great Plains (after Guthery and Bryant 1982).

1.4 STATUS OF PLAYA WETLANDS

Playa lakes and wetlands of the Southern Great Plains have undergone major changes as a result of human activity, primarily from irrigated crop production and grazing of cattle. Regional changes, particularly from alterations to playa basins made to expand the irrigation water supply (Figure 1-6), have coincidentally benefited and harmed a variety of wildlife populations that depend on the scarce aquatic environments of this semiarid region. Some localized playa habitats have been severely degraded while others have been considerably enhanced, particularly for waterfowl. Because the common resident and migratory species have unique optimum habitat requirements, some populations have gained and others have lost habitat values that promote their survival and welfare.

On balance, wildlife abundance has apparently increased in the Southern Great Plains among some of the important game and non-game species, due in all probability to increased water, cover and food supplies at farmland playas, especially those surrounded by irrigated croplands (Figure 1-7). Current regional projections, however, portend less water availability and grain crop production favorable to wildlife, factors that will reduce playa habitat carrying capacity and wildlife abundance in the future unless present schemes to import water from other regions are carried out.

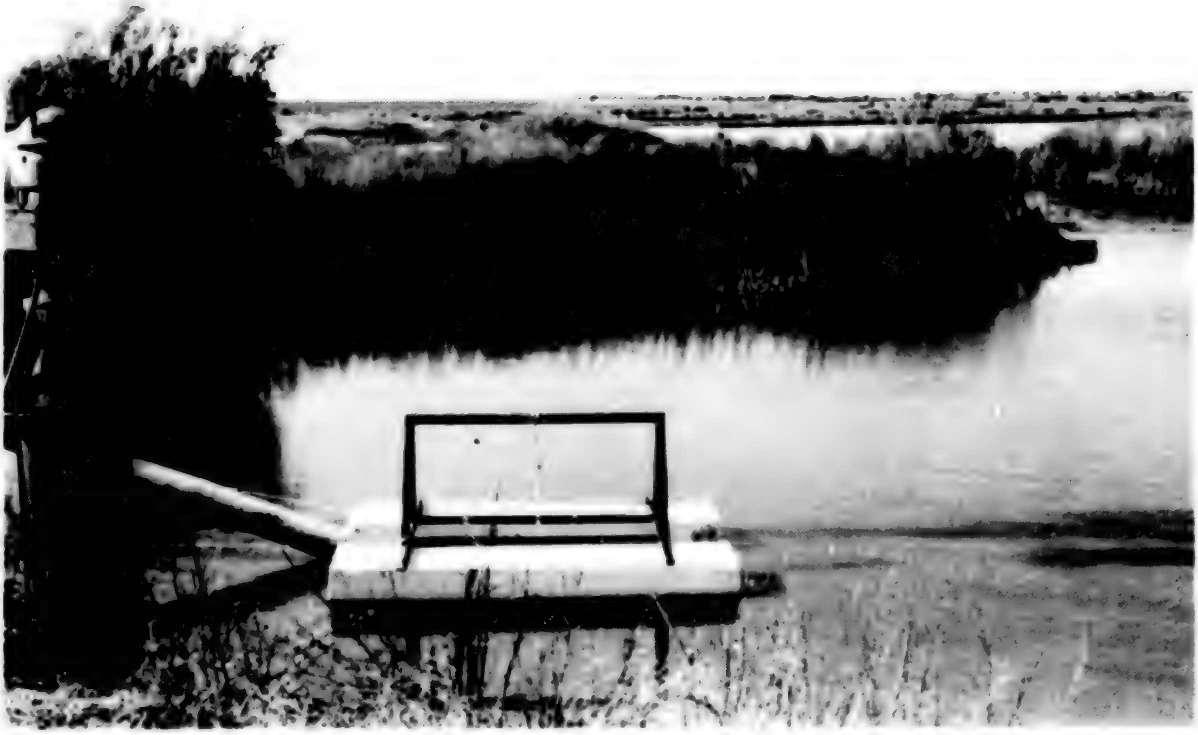

Figure 1-6. Impoundment and recycling of surface runoff into playa basins from irrigated croplands and cattle feedlots have considerably augmented the irrigation water supply and reduced pumping costs (as compared to pumping from deep wells), while also promoting open water and vegetative cover for wildlife (Nelson and Associates, Inc. 1981).

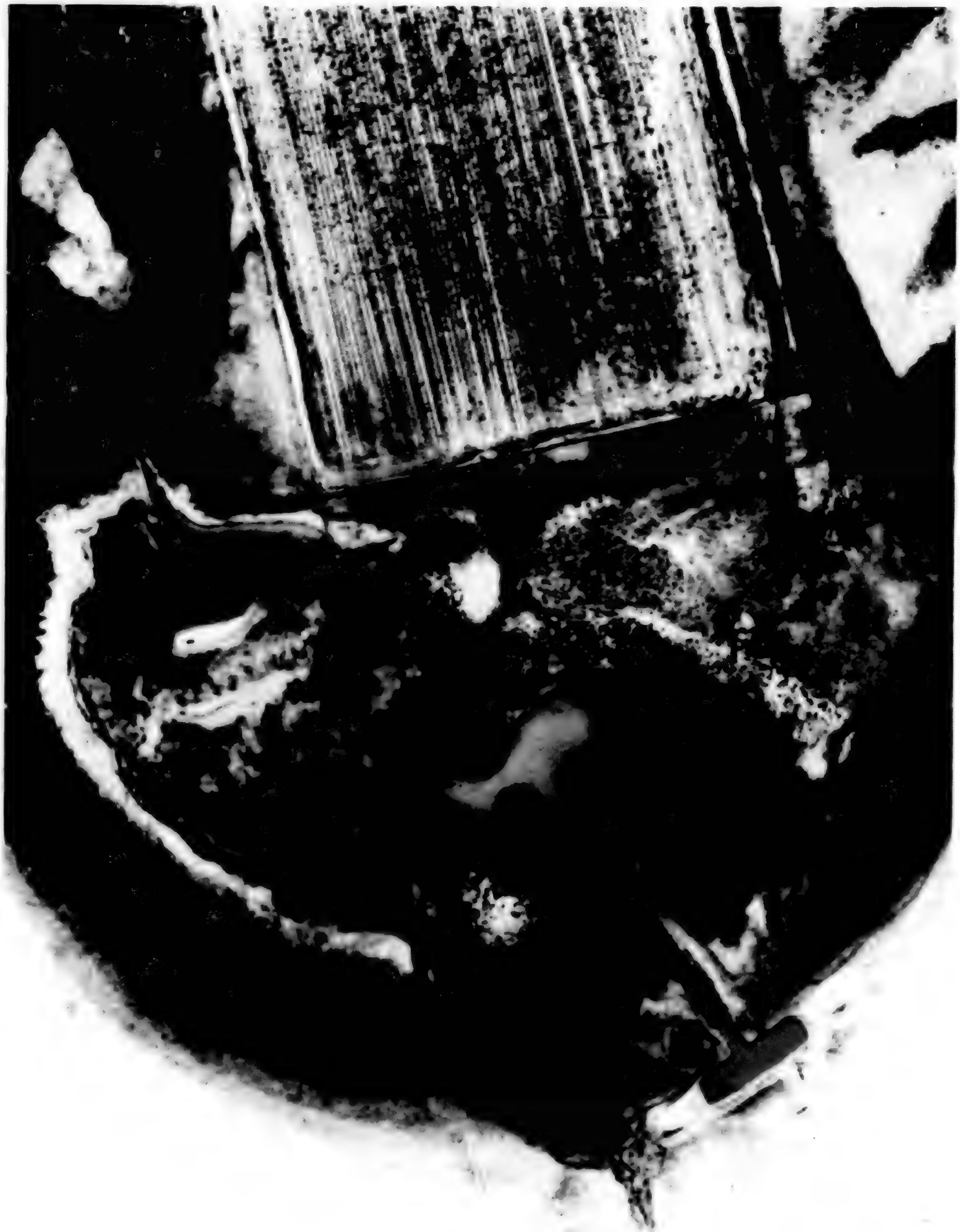

Figure 1-7. Modified playa, having a pit excavated on the basin perimeter, receives irrigation runoff from surrounding croplands, resulting in greater wildlife habitat diversity and carrying capacity that is characteristic of a persistent, emergent, palustrine wetland (Texas Tech University, Department of Range and Wildlife Management 1981).

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2.0 PLAYA REGIONAL GEOGRAPHY

Playa basins occur in many arid or semiarid regions of the world. In the United States they concentrate in the Southern Great Plains as either ephemeral or permanent lakes or wetlands. The semiarid regional climate ranges from dry steppe to warm temperate, and the main geologic feature is the underlying Ogallala Aquifer. The dominant landform is smooth plains; natural land cover is mostly shortgrass prairie and the basic land use is agricultural, with irrigated farmlands clustered near the center of the study region. The flat topography is generally devoid of stream drainage; playas collect runoff and evaporate rapidly. The geohydrology involves the comparative isolation of subsurface aquifers because of impermeable clay in playa bottoms. Playas number about 25,000 within the 68,500-mi^2 (177,400-km^2) region, occasionally ranging in size up to several hundred acres (over 100 hectares); the majority are under 10 ac (4 ha). Their size distribution is uneven, with larger playas concentrating near the center of the region.

2.1 THE OCCURRENCE OF PLAYAS

Playas are the flat central portions of arid basins that drain internally, periodically flood, and accumulate sediment (Neal 1975). These shallow, plate-like depressions occur in desert and semiarid regions of the world such as the Sahara, southern Iran, western Australia, the U.S.S.R., and the Southern Great Plains of the United States, as well as in Utah, Nevada, Oregon, California, and Arizona. As many as 50,000 playas a few square kilometers in size occur throughout the world (Neal 1975).

Playas are referred to by many names, including *salar* in Spanish-speaking regions, *sabkha* in north Africa, and *pans* or *salt pans* in south Africa and Australia. In English-speaking regions, they are termed *dried lakes*, an obvious misnomer for dry lake beds; *playa lakes* which are flooded playa basins (Neal 1975); and *salt playas*. The term "playa" itself comes from the Spanish for "shore" or "beach." The variety of terms given to playas illustrates that they have various distinguishing features.

Playas generally can be divided into two main types: ephemeral and permanent. In a wet condition, the playa basins are either *lakes* having little to no vegetation, or *wetlands* with aquatic vegetation. Both persistent and intermittent lakes and wetlands occur within the Southern Great Plains.

The Southern Great Plains. Playa wetlands in the U.S. are associated primarily with the region known as the Southern Great Plains, which encompasses high tablelands in southeastern Colorado, southwestern Kansas, the Oklahoma Panhandle, eastern New Mexico, and north-central Texas, including the Texas Panhandle. The region defined for the study of wildlife associated with Southern Great Plains playa lakes and wetlands covers 60 counties—one in Colorado, eight in Kansas, four in Oklahoma, four in New Mexico, and 43 in Texas. The approximate average acreage of dry playa basin surface per square mile (or ha/km^2) within the five zones of the study region depicts the surface density of playas (Figure 2-1).

2.2 THEORIES OF PLAYA BASIN ORIGIN

There are seven theories to explain the origin of playas, including the development of karst topography, land subsidence, the isolation of early pluvial lakes and river courses, soil slumpage, wind deflation, the occurrence of buffalo wallows, and meteor impact. There is some evidence that all of these processes occurred on the Southern Great Plains.

The development of *karst topography*, in which sinkholes appear in the dissolving limestone caprock, is not extensive in the Southern Great Plains, but some sinkholes

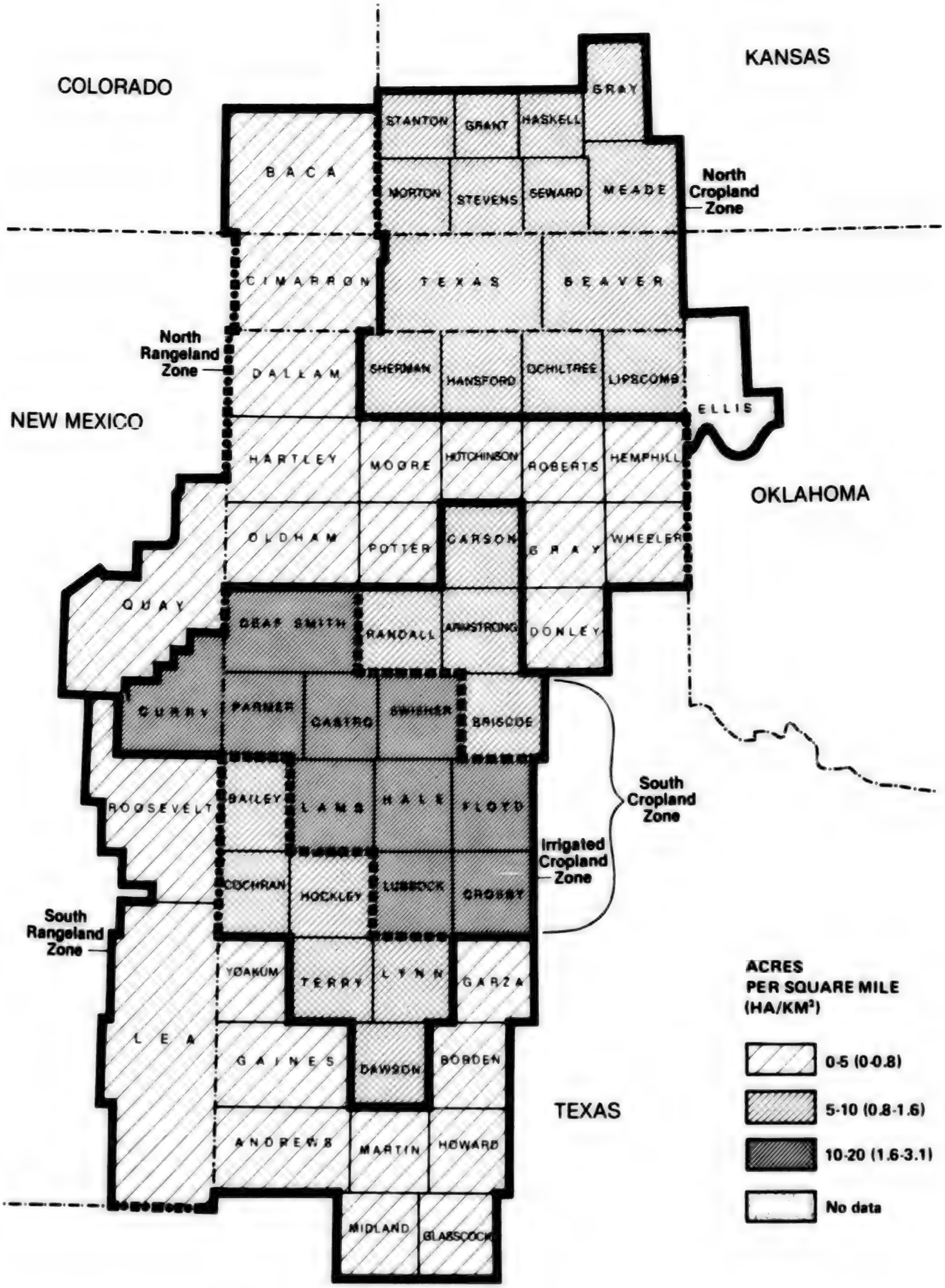

Figure 2-1. Average dry playa basin surface density, by zones of the study region (adapted from Schwiesow 1965, Dvoracek and Black 1973, and Guthery et al. 1981).

occur in Armstrong, Briscoe, Glasscock, and Lipscomb Counties, Texas. South of Big Springs in Howard County, sinkholes in cretaceous limestone may indicate some karst development (Reeves 1966).

Land subsidence, in which overlying sediments compact to conform with the topography of underlying strata also is a theory for playa formation (Rettman 1981; Reeves 1966). There is some evidence of playa basin development by this process in Armstrong, Briscoe, and Lipscomb Counties, Texas, according to Reeves. Because the Ogallala Aquifer was deposited in hills and valleys, deposits of thicker sediments filling the valleys could correspond with areas where subsidence would cause playa development.

The isolation of early Pleistocene *pluvial lakes* and streams was caused by reduction of precipitation and runoff and an associated increase in evaporation rate when the Southern Great Plains developed into a semiarid region. The presently flat topography covers drainage courses existing during wetter pluvial periods. Most of these early stream valleys and depressions were filled with Eolian and fluviatile debris, but some depressions remain as playa basins. Large depressions occur only where the Ogallala formation is less than 100 ft (30 m) thick, suggesting that in areas of greater thickness the pluvial streams did not cut deep enough to create lasting basins (Reeves 1966). Playas developed by this process such as Lubbock Lake (Lubbock County, Texas), which formed about 13,000 years ago, have a generally linear shape. Some west Texas lakes lie along paleodrainage, including pre-Ogallala drainage courses that still channel runoff after storms or are evident in subsurface channels.

Soil slumpage, in which salt or other soluble materials (other than limestone) are dissolved, causing sinks, is fairly rare in the Southern Great Plains, although it may have had some role in the formation of saline lakes. Sinks in which sodium sulfate has been dissolved in underlying strata have been found in Rich and Brownfield playas in Terry County, Texas (Reeves 1966).

The most credible theory of playa development, and one which describes the formation of the most circular or oval Great Plains playas, concerns the process of *wind deflation* or *blowouts*. The formation of clay dunes or lunettes near playas is highly suggestive of this process (Price 1972). In semiarid regions such as the Southern Great Plains, other factors besides flat terrain and high and constant winds contribute to the potential for wind erosion. When clayey sediments dry, a thin crust forms and breaks into polygonal cakes (Price 1972; Neal 1965). Price observed that evaporated salts such as chlorides will crystallize, causing the crust to break into fine dust particles easily transported by wind. The presence in the Southern Great Plains of "oriented" lakes—basins arranged in parallel patterns with their axes aligned—further supports the wind deflation theory. Oriented lakes characteristically occur in semiarid regions having bimodal wind patterns where the average directions are nearly opposite (Price 1972). This phenomenon tends to elongate basins from round to oval.

Playas often have been called *buffalo wallows*, but it is doubtful that buffalo played much part in playa formation. Playas have always attracted wildlife, either for cover, water, or salt, and, although buffalo can carry a substantial amount of soil in their fur (Rettman 1981), it is unlikely that they could do more than deepen existing depressions.

There are several basins near Odessa, Texas, which were caused by a *meteor impact*, but most Great Plains playas lack the characteristics of a meteor crater, such as angular fragments of rock on the rim and fragments of a meteor.

2.3 REGIONAL CLIMATE AND GEOLOGY

The climate of this region is classified generally as mid-latitude semiarid (Critchfield 1966). Although northern and western portions fit this classification, the climate can range from dry steppe in the southern district to warm temperate in eastern sections (Curtis and Beierman 1980).

Winter temperatures range significantly from north to south in the study region. Record summer highs have reached 109-112° F (43-44°C); extreme winter lows have ranged from -8°F (-22°C) in the south to -18°F (-28°C) in the north (Gale Research Co. 1980). In Amarillo, near the center of the study region (Potter County, Texas), normal daily highs exceed 90°F (32°C) in July, and normal daily lows are in the low 20's (-5°C) in January (Figure 2-2). The freeze-free period normally ranges between 180 and 210 days from northwest to southeast through the study region.

The mean annual precipitation generally decreases from northeast to southwest in the study region; the low level is about 15 in (38 cm) in the south (Dawson County, Texas) and the high is about 21 in (53 cm) in Gray County, Texas (Figure 2-3). On the average, more than an inch (3 cm) of rain falls each month between April and October; May and June are the wettest months with 2-4 in (5-10 cm) (Dvoracek and Black 1973).

The winds in the Southern Great Plains generally blow from southwest to northeast with a more pronounced southerly-to-northerly flow in the summer. Wind speeds can range between 40 and 60 mph (64-97 kph) for as long as a day in March, April, and May (Traweek 1981); the highest average wind speed (7 mph or 11 kph) occurs in the summer.

Evaporation rates are high in the semiarid climate of the Great Plains. The mean annual Class A pan evaporation is about 96 in (244 cm) near Amarillo (Potter County) and 112 in (284 cm) at the southern limit of the study region (Figure 2-4). The highest evaporation rates occur in midsummer with low precipitation and high winds.

Geologic Features of the Southern Great Plains. About 250 million years ago during the Permian Period of the late Paleozoic Era, the Southern Great Plains was submerged under a shallow inland sea. During the early Mesozoic Era, the High Plains region was lifted above sea level; Permian rocks were eroded and deposited as the Triassic Red Beds—impervious layers underlying the Ogallala formation. In the Cretaceous Period of the late Mesozoic Era, shallow seas again covered parts of the High Plains; shales and limestones of the Trinity and Fredricksburg groups were deposited in shallow waters (Figure 2-5). Some of these formations are evident along the south and southeastern edges of the study region.

In the late Tertiary Period, during the Pliocene Epoch some 10 million years ago, uplift of the Rocky Mountains region caused streams to cut deep canyons through the Cretaceous rocks. These were deposited as alluvial fans with thick layers of wet gravel on the eastern edge of the Rockies. The gravel deposits trapped much of the stream runoff, which is now the Ogallala Aquifer underlying most of the study region (Figure 2-5). During the Pleistocene Epoch in the Quaternary Period, the climate turned from wet to dry and windblown sand and Aeolian sediments covered the Ogallala; these sediments became the soils of the Southern Great Plains. Dunes of this sand are present along river valleys in the northeastern part of the study region. During the Quaternary Period, the Southern Great Plains became elevated smooth plains with the flow of surface water diverted southward in the Pecos and eastward in the Canadian River drainage.

Soil Regions of the Southern Great Plains. Soils of the Southern Great Plains are represented by three orders: *alfisols*—

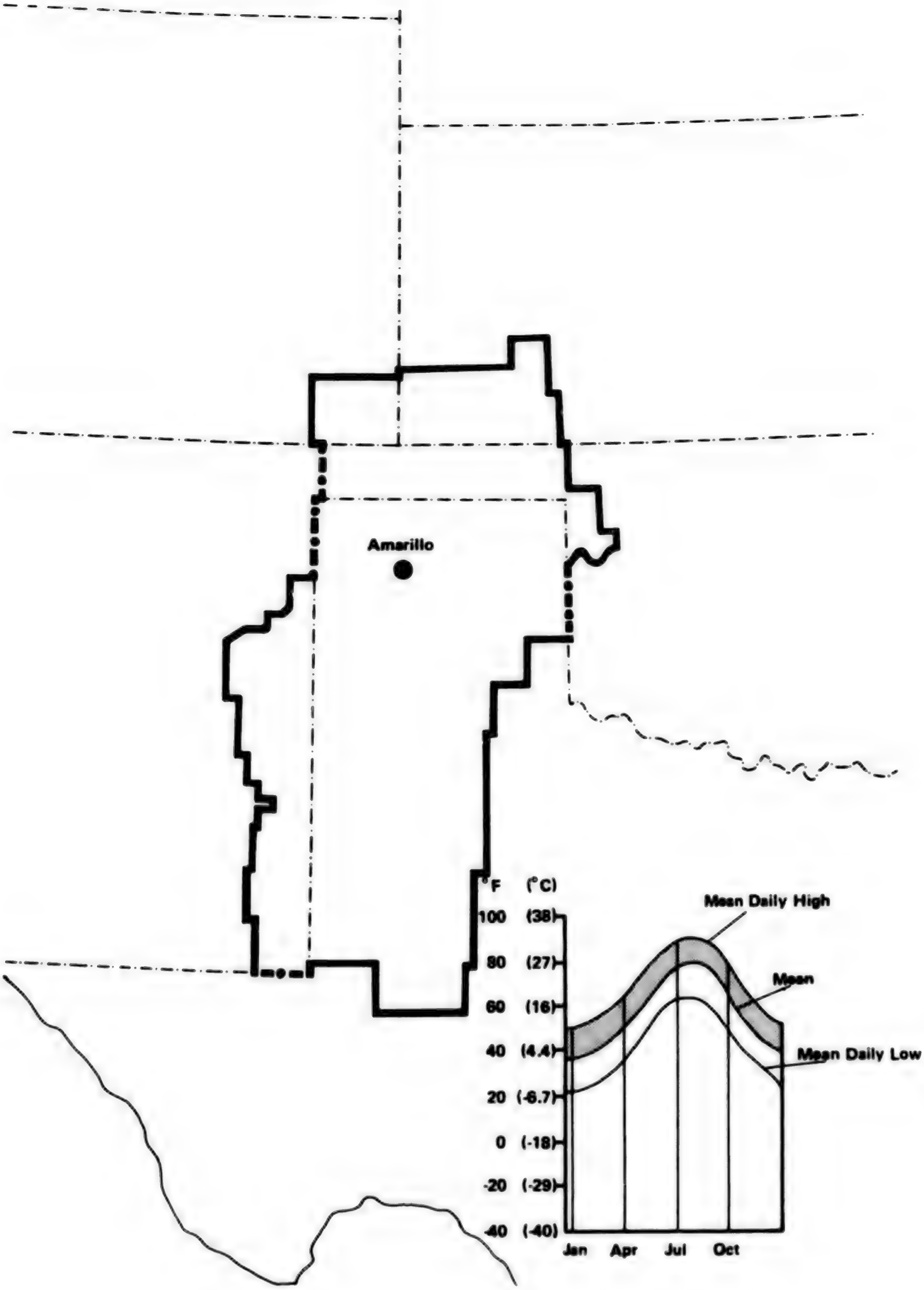

Figure 2-2. Average temperatures at Amarillo, Texas, in the Southern Great Plains (U.S. Geological Survey 1970).

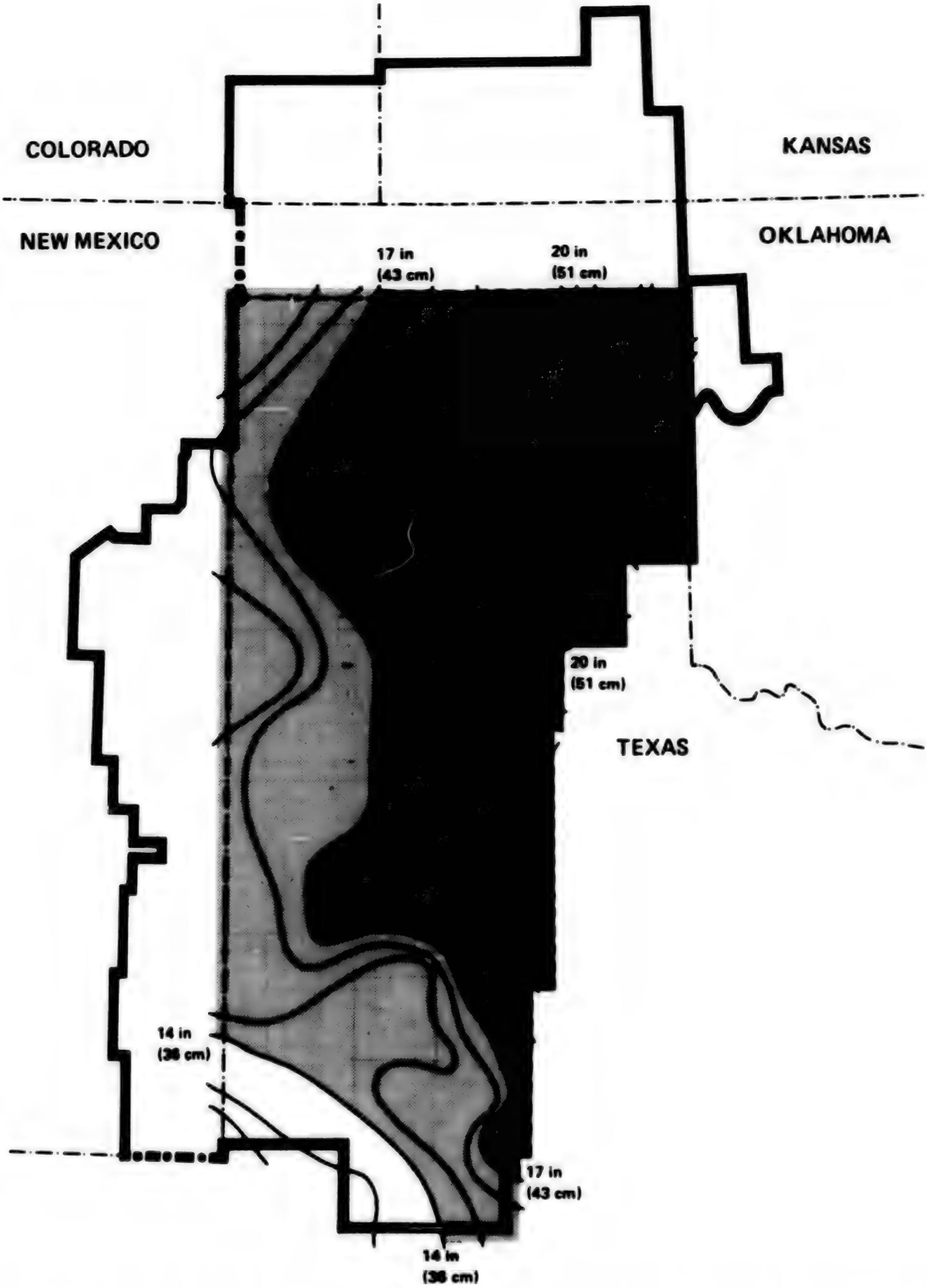

Figure 2-3. Distribution of average annual precipitation on the Texas High Plains (Dvoracek and Black 1973).

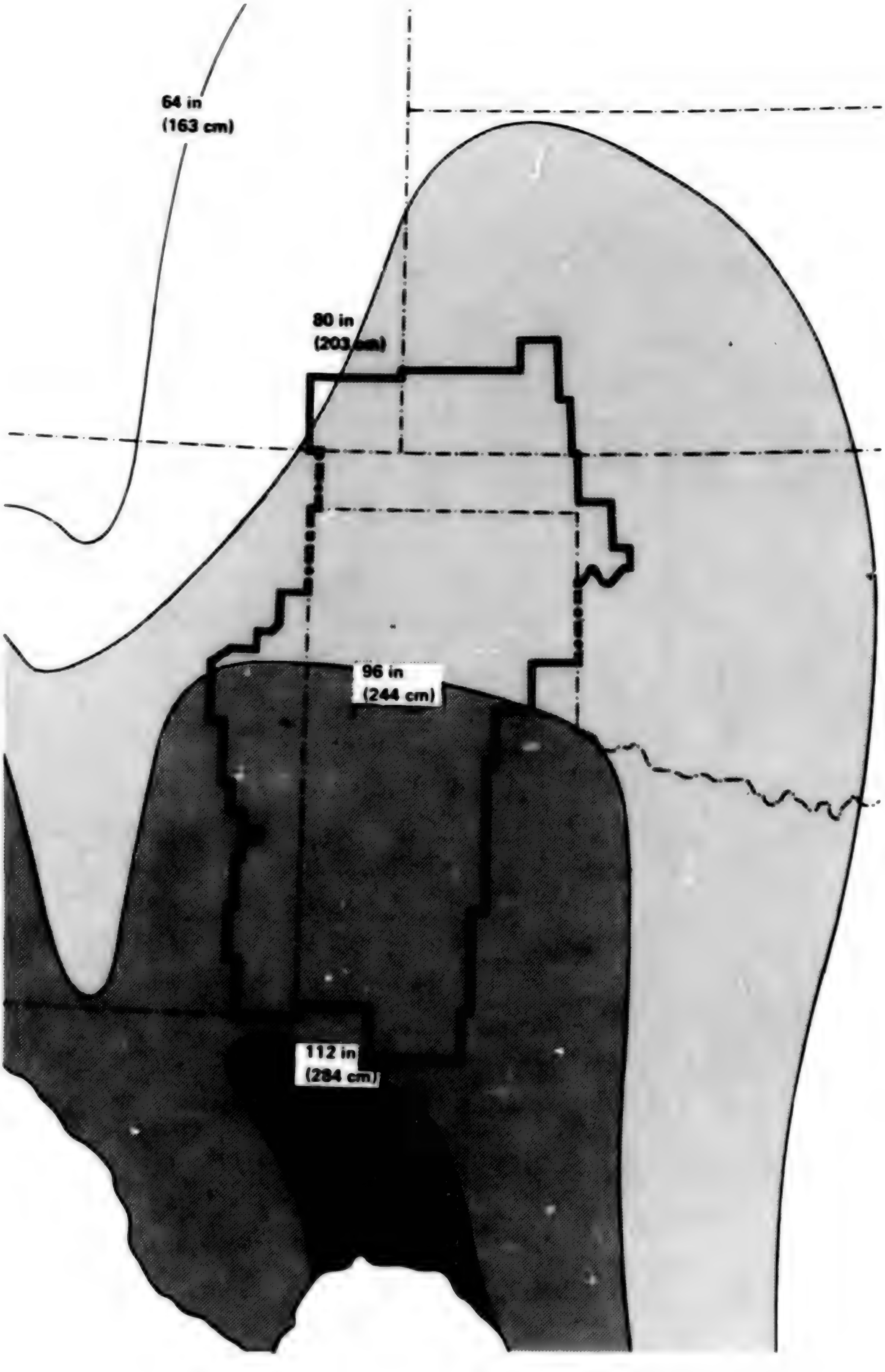

Figure 2-4. Mean annual pan evaporation in the Southern Great Plains region (U.S. Geological Survey 1970).

ERA	PERIOD	EPOCH (years ago)	GROUP	Formation	Description	Approximate Thickness (ft) (m)
Cenozoic	Quaternary	Recent (0-10,000)			Valley alluvium. Stabilized and active dunes. Black, brown, and white saliferous playa silts.	n.a.
					UNCONFORMITY	
		Pleistocene (10,000-1,000,000)		Tahoka	Clay and sand, gray. Bentonitic and calcareous.	35 (11)
					UNCONFORMITY	
				Tule	Clay and sand, gray and bentonitic. Thin-bedded, ripple-marked, freshwater limestones.	100 (30)
					UNCONFORMITY	
				Blanco	Sand and clay, light gray. Bentonitic clays. Some freshwater limestone and diatomite.	70± (21±)
					UNCONFORMITY	
	Late Tertiary	Pliocene (1,000,000–10,000,000)	Ogallala	Bridwell	Clay and sand, reddish-brown. Coarse channel gravels. "Cap-rock" at top.	155± (47±)
					UNCONFORMITY	
				Couch	Sand, pinkish-gray. Well sorted, thick basal gravel.	125± (38±)
					UNCONFORMITY	
Late Mesozoic	Early Cretaceous	Comanchean (70,000,000 +)	Washita	Duck Creek	Shale, yellow-brown to dark gray. Brown limestone and sandstone. *Desmoceras* abundant at base.	0-40 (0-12)
					UNCONFORMITY	
			Fredericksburg	Kiamichi	Shale, dark gray to yellow-brown. Thin gray to yellow-brown limestone and sandstone lentils. Lower part fossiliferous.	108 (33)
				Edwards	Limestone, white to yellow-brown. Thick to massive-bedded.	20-30 (6-9)
				Comanche Peak	Limestone, light gray. Thick to massive-bedded, and argillaceous. Marl interbeds.	50-80 (15-24)
				Walnut	Shale, light gray. Sandy, light gray. Argillaceous limestone abundant.	8-23 (2.5-7)
					UNCONFORMITY	
			Trinity	Paluxy	Sand, light gray to purple. Lenticular quartz gravel beds.	10-25 (3-8)

Figure 2-5. Stratigraphic section of the Texas High Plains (after Reeves 1966).

non-calcic brown, gray-brown, or gray woodland soils; *mollisols*—chestnut and reddish prairie soils; and *aridisols*—reddish-brown and red desert soils (Buol, Hole and McCracken 1973) (Figure 2-6). Aridisols have clay horizons but limited profile development, low organic matter, and high levels of exchangeable bases. In the Southern Great Plains, they are usually dry in all horizons, and never moist as long as 90 consecutive days when temperatures are suitable for plant growth. Mollisols have well-developed horizons with nearly black, organic-rich surface layers and medium to high base supply. Mollisols of the region are dry more than 90 cumulative days in the year. Alfisols often have well-developed profiles with subsurface horizons of clay accumulation, moderate organic material, and medium to high base supply. Regional alfisols are dry more than 90 cumulative days when temperatures are suitable for plant growth.

The Llano Estacado of the Southern Great Plains (Texas-New Mexico High Plains) has been subdivided into three broad zones of soil surface texture representing fine, medium, and coarse soils (Figure 2-7). Other, less extensive soil texture types occur within these broad zones. Allen et al. (1972) reported that surface soils in the "fine" zone were clay loams and silty clay loams, typically of the Pullman soil series. Soils of the "medium" zone, representative of the Amarillo soil series, consist primarily of fine sandy loams, with sandy clay loams and loams quite common in occurrence. The "coarse" soil zone is dominated by loamy fine sands and fine sands of the Arvana or Douro soil series.

2.4 LANDFORMS, LAND COVER, AND LAND USE

The topography of the Southern High Plains is fairly uniform. Hammond used two main *classes* to distinguish between land surface forms in this region: Plains and Tablelands. There are two *subclasses* of Plains: Smooth Plains and Irregular Plains. The Smooth Plains in the study region have more than 80% gently sloping surface, and 50 to 75% of their surface is upland terrain; the Irregular Plains are less gently sloping and predominantly lowland terrain. Most of the region would be classed as Smooth Plains.

The Tablelands in the study area belong to one subclass having moderate relief and 50 to 80% gently sloping surface. The slope of the Tablelands running east-west along the Canadian River Breaks is 50 to 75% on uplands, but in Borden, Crosby, Garza, and Howard Counties, Texas, at the southeastern edge of the study region, the same slope is predominantly on lowlands. The Tablelands generally are bounded by valley escarpments.

Bailey's Ecoregions. The Southern Great Plains can be described among three of Bailey's Ecoregions, which differentiate areas having similar climate and types of vegetation classified in a hierarchical scheme with four main levels. The top level is *domain*, which can be defined as a subcontinental region with similar climate (Cowardin et al. 1979). The Southern Great Plains are divided between two domains—Dry and Humid Temperate. The second classification level is the *division* which further describes climate regionally. The Humid Temperate Domain in the Southern Great Plains has only one division—Prairie, as does the Dry Domain—Steppe. The third level of Bailey's classification scheme is the *province*, which describes broad vegetational classes. The Steppe Division encompasses only one province in the study region—Great Plains Shortgrass Prairie, while the Prairie Division contains the Prairie Brushland and Tall Grass Provinces.

The fourth level in Bailey's classification is the *section*, which describes dominant or climax vegetation and coincides closely with Kuchler's (1964) potential vegetation types (Figure 2-8). The Prairie Brushland Province primarily has a *grama-buffalo grass* association, which can be found along the eastern edge of the study region. Because of

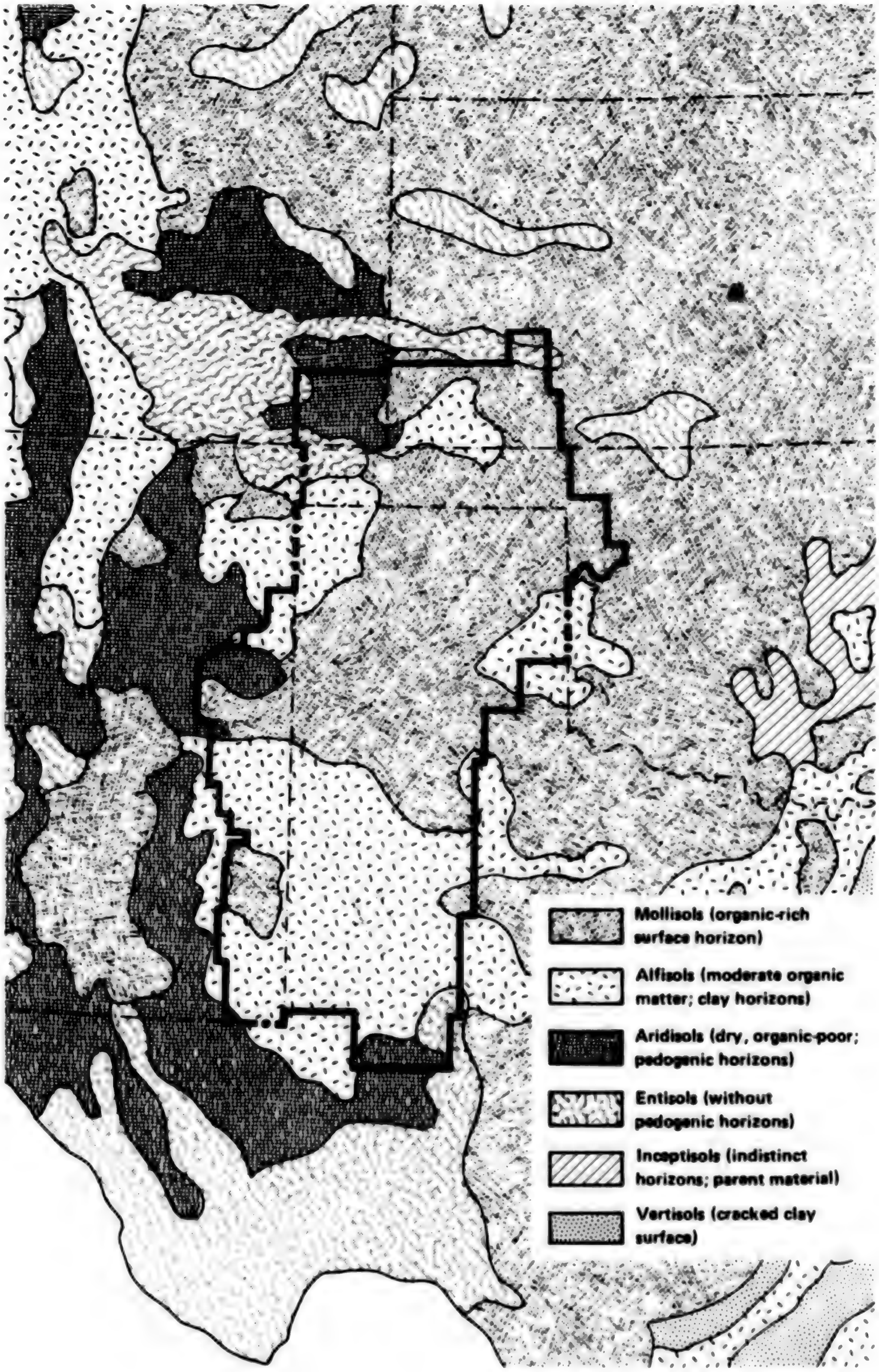
Mollisols (organic-rich surface horizon)
Alfisols (moderate organic matter; clay horizons)
Aridisols (dry, organic-poor; pedogenic horizons)
Entisols (without pedogenic horizons)
Inceptisols (indistinct horizons; parent material)
Vertisols (cracked clay surface)

Figure 2-6. Distribution of principal soil orders in the Southern Great Plains (U.S. Geological Survey 1970).

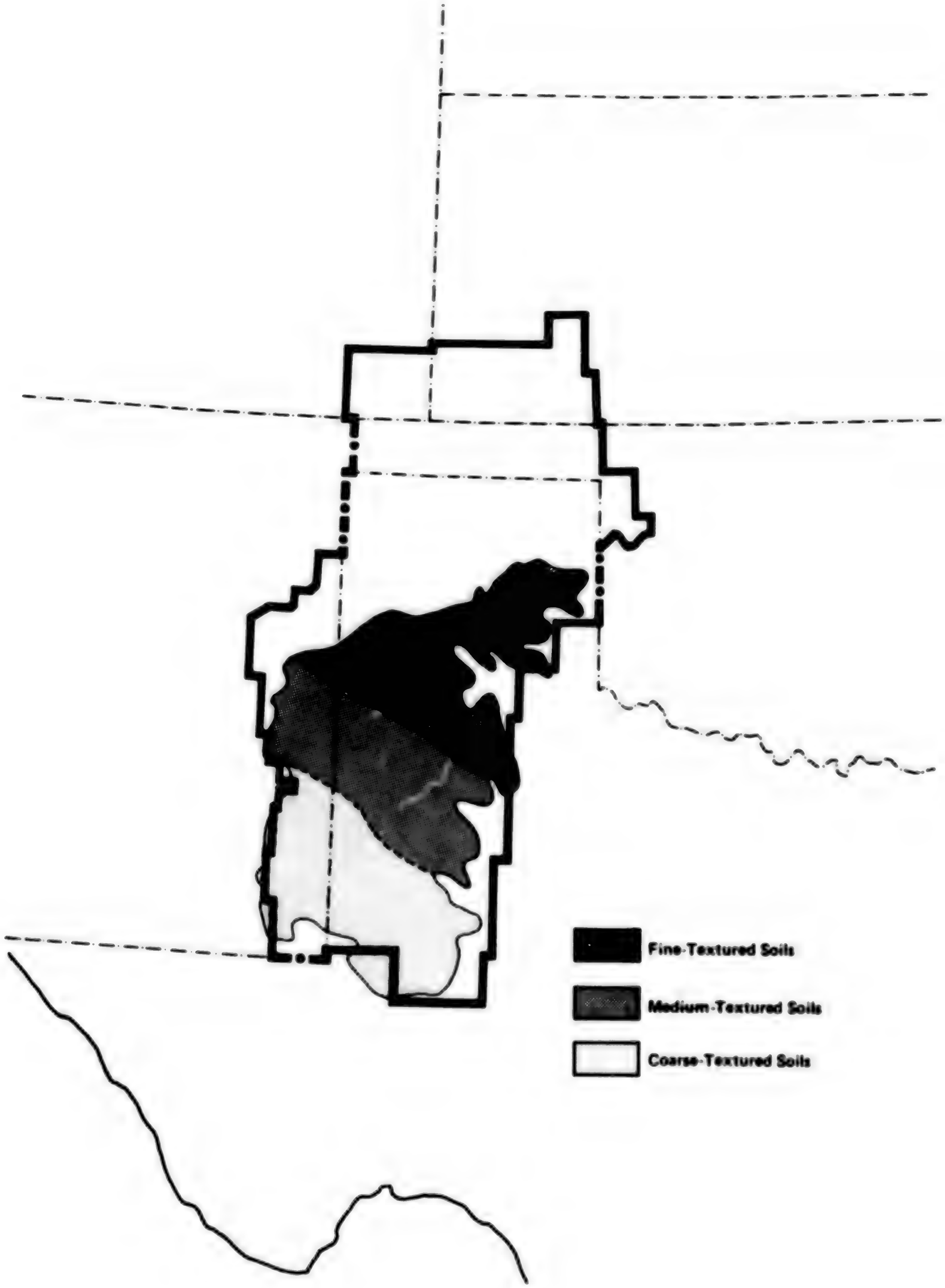

Figure 2-7. Soil texture zones of the Llano Estacado or Southern High Plains (Harris et al. 1972).

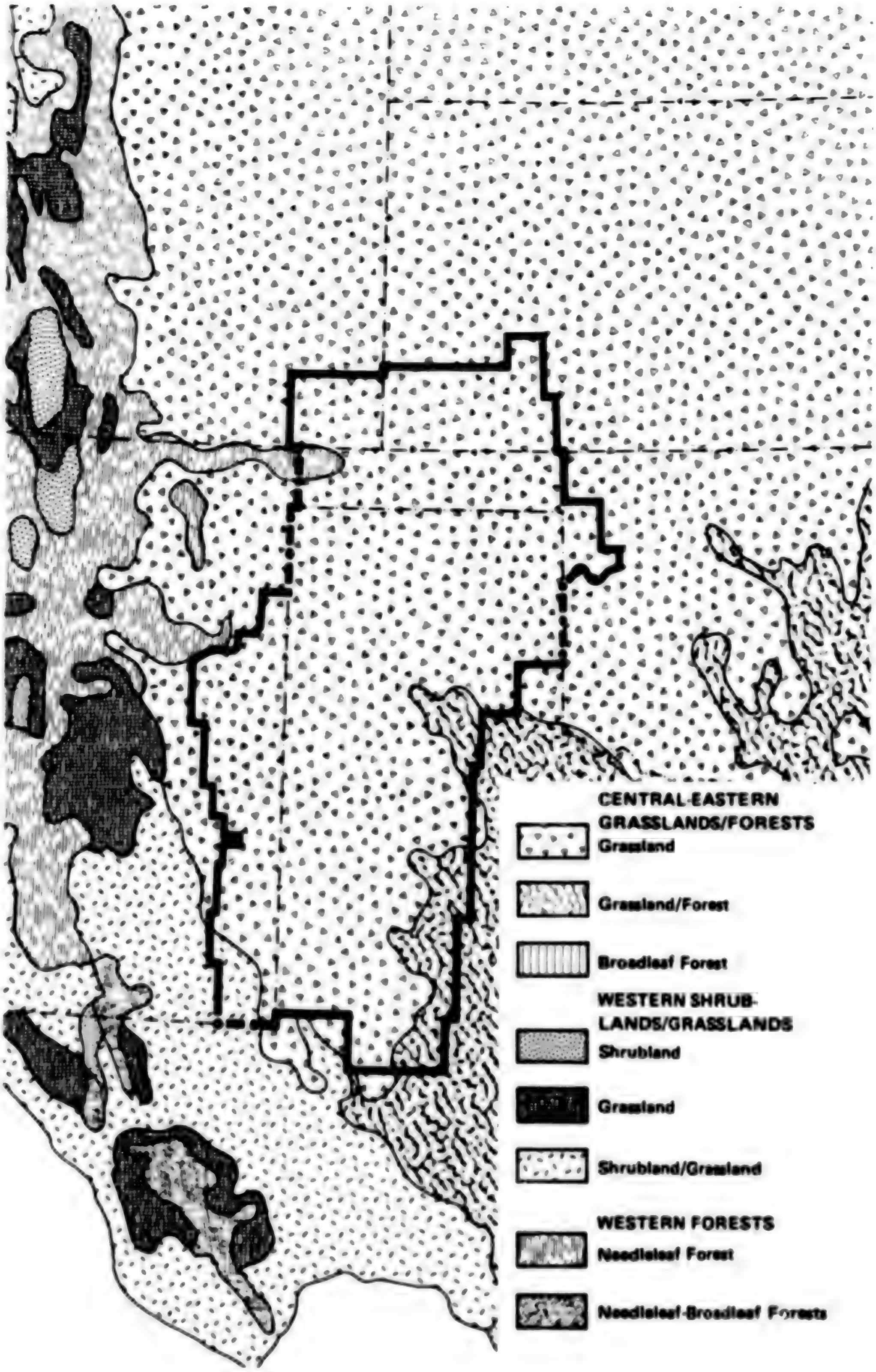

Figure 2-8. Potential natural vegetation after Kuchler (1964) for the region of the Southern Great Plains (U.S. Geological Survey 1970).

overgrazing, the brush species of mesquite has invaded the area, causing a weed problem for ranchers (Gould 1968).

The Tall Grass Prairie Province has a post-climax community dominated by big bluestem and the associated midgrass–blue grama. The *bluestem-grama* association is present only in Donley, Gray, and Hemphill Counties, Texas, near the central eastern edge of the study region; and in Gray, Haskell, Meade and Seward Counties, Kansas. There are few stands left of these grasses because most land has been cultivated. The soils here are usually fertile mollisols (Brabander 1981). According to Kuchler (1964), the Great Plains Shortgrass Prairie Province has *grama-buffalo grass* as the dominant vegetation. It is prevalent west of the *bluestem-grama* association, being more adapted to the drier conditions in the main portion of the study region (Figure 2-8).

Kuchler's classification scheme recognizes three additional classes of vegetation: *juniper-pinyon woodlands*, present in Baca County, Colorado, and Cimarron County, Texas, in the northwest corner of the study region; *sandsage-bluestem prairie*, present in Morton, Seward, and Stevens Counties, Kansas; and *shinnery oak*, present along the Canadian River Breaks. Shinnery oak habitat includes clumps of low-growing oaks interspersed with big bluestem.

Cowardin's Wetland Classification. The playa basins of the Southern Great Plains are considered wetlands according to Cowardin's Classification of Wetlands and Deepwater Habitats (Table 2-1). They have two attributes of wetlands: at least intermittently the land supports aquatic plants (hydrophytes); and the substratum is predominantly undrained hydric soil (Cowardin et al. 1979).

Cowardin's system for classifying wetlands is hierarchical; the highest level is the *system*. Of five defined systems, playas fit into two: Lacustrine (lakes) and Palustrine (marsh, swamp, bog, fen, or wet prairie). The *subsystem* is the next level: Lacustrine has two subsystems—Limnetic and Littoral; Palustrine has none. The *class* is the next level of the hierarchy and identifies substrate material, water regime, or vegetative type; the *subclass* further defines these identifiers. *Dominance type* is a level subordinate to subclass and describes dominant plant or animal species. There are also special modifiers, including *water regime* modifiers, *water chemistry* modifiers, and others which describe animal or human modifications to the wetland.

Some of the larger playas of the Southern Great Plains fit into the Lacustrine System (Figure 2-9). Only those over 20 ac (8 ha), and probably many of those identified by name on maps, would fall into the Limnetic Subclass; most Lacustrine playas would conform to the Littoral Subclass. The great majority of playas belong to the Palustrine System (Figure 2-10), as they lack the depth and extent of open water necessary to be classed as Lacustrine.

The Fish and Wildlife Service National Wetland Inventory (NWI) uses a sequence of letters and numbers (alpha numerics) to identify each wetland on an NWI map (U.S. FWS, undated). The first letter in the sequence represents the system; subsequent digits (up to five) represent the subsystem, class, subclass, and special modifiers (Table 2-1). Some wetland inventories lack subclass and special modifier designations since mapping has been accomplished at various levels of detail based on regional needs and capabilities.

The following is an example illustrating how the NWI classification system should work to describe a large playa with more than 20 ac (8 ha) of open water, at least a 2-m depth, and a dike on one side:

L1UB3Gh
(L) *System*: Lacustrine
(1) *Subsystem*: Limnetic
(UB) *Class*: Unconsolidated Bottom

Table 2-1. Playa-related wetland classification according to Cowardin et al. (1979).

Classification Level	Alpha Numeric Code	Attributes
Lacustrine System	(L)	Situated in a topographic depression. Lacks persistent vegetation on more than 30% of surface area. Total area is 20 ac (8 ha) or more, or at least 2 m deep with wave-formed or bedrock shoreline. Ocean-derived salinity is less than 0.5%.
Limnetic Subsystem (Lacustrine System)	(1)	All deepwater habitats within Lacustrine below a depth of 2 m.
Littoral Subsystem (Lacustrine System)	(2)	All wetland habitat within Lacustrine from shoreline to a depth of 2 m.
Palustrine System	(P)	All non-tidal wetlands dominated by vegetation. Areas that lack vegetation but which are all of the following: less than 20 ac (8 ha); lack wave-formed or bedrock shoreline; water depth is less than 2 m; ocean-derived salinity is less than 0.5%.
Unconsolidated Bottom Class	(UB)	Unconsolidated substrates with at least 25% cover of particles smaller than stones. Vegetative cover is less than 30%.
Sand Subclass	(2)	Unconsolidated particles smaller than stones are predominantly sand; finer and coarser sediments may be intermixed.
Mud Subclass	(3)	Unconsolidated particles smaller than stones are predominantly silt and clay; coarser or organic material may be intermixed.
Unconsolidated Shore Class	(US)	Unconsolidated substrates with less than 75% of the surface area composed of stones, boulders, or bedrock. Less than 30% cover of vegetation other than pioneering plants. Any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artifically flooded.

Table 2-1. (continued)

Classification Level	Alpha Numeric Code	Attributes
Sand Subclass	(2)	Same as for UB Class.
Mud Subclass	(3)	Same as for UB Class.
Emergent Wetland Class	(EM)	Wetland characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. Dominated by perennials. Vegetation is present for most of growing season most years. All freshwater regimes included.
Persistent Subclass	(1)	Wetland dominated by species that normally remain standing until at least beginning of next growing season. Only in Palustrine System.
Non-persistent Subclass	(2)	Wetland dominated by plants which fall to substrate or below water surface at end of growing season, so that in certain seasons there is no sign of emergent vegetation.
Scrub-shrub Wetland Class (Palustrine System only)	(SS)	Wetland dominated by woody vegetation less than 6 m tall. Includes true shrubs, young trees, or stunted shrubs and trees. All freshwater regimes included.
Broad-leaved Deciduous Subclass	(1)	Dominated by deciduous and broad-leaved shrubs and trees.
Needle-leaved Deciduous Subclass	(2)	Dominated by deciduous and needle-leaved shrubs and trees.
Temporarily Flooded Water Regime	(A)	Surface waters present for brief periods in growing season. Water table well below surface most of season. Both upland and lowland plants grow here.
Saturated Water Regime	(B)	Substrate is saturated to surface for extended periods of growing season. Surface water seldom present.

Table 2-1. (continued)

Classification Level	Alpha Numeric Code	Attributes
Seasonally Flooded Water Regime	(C)	Surface water present for extended periods, especially in early growing season; absent by end of season most years. Water table often near surface when surface water is absent.
Semi-permanently Flooded Water Regime	(F)	Surface water persists throughout growing season most years. When surface water absent, water table at or near land surfaces.
Intermittently Exposed Water Regime	(G)	Surface water present throughout the year all years except during extreme drought.
Permanently Flooded Water Regime	(H)	Water covers surface throughout year all years. Vegetation is composed of obligate hydrophytes.
Intermittently Flooded Water Regime	(J)	Substrate usually exposed, but surface water occurs occasionally without seasonal predictability. Plant communities change as moisture regime changes. May not be a wetland if there is a lack of hydric soils or hydrophytes.
Artificially Flooded Water Regime	(K)	Amount and duration of flooding controlled by man with pumps or siphons. Rice-soybean agricultural lands and wildlife management areas are examples; not irrigated pastureland.
Modifier for partially drained/ditched	(d)	Water level has been artificially lowered by ditching, but soil moisture is sufficient to support hydrophytes.
Modifier for farmed	(f)	Soil surface has been cultivated for farming crops. Hydrophytes will become reestablished if farming discontinued.
Modifier for diked/impounded	(h)	Dike obstructs inflow of water. Impoundment obstructs outflow of water.
Modifier for excavated	(x)	Basin was excavated by man.

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Table 2-1. (concluded)

Classification Level	Alpha Numeric Code	Attributes	
Modifier for hypersaline	(7)	>40 ppt (salinity)	>60,000 μMhos (25°C)
Modifier for eusaline	(8)	30.0 - 40.0 ppt	45,000 - 60,000 μMhos
Modifier for mixosaline	(9)	0.5 - 30.0 ppt	800 - 45,000 μMhos
Modifier for fresh	(0)	<0.5 ppt	<800 μMhos
Modifier for acid	(a)	pH <5.5	
Modifier for circumneutral	(t)	pH 5.5 - 7.4	
Modifier for alkaline	(l)	pH >7.4	

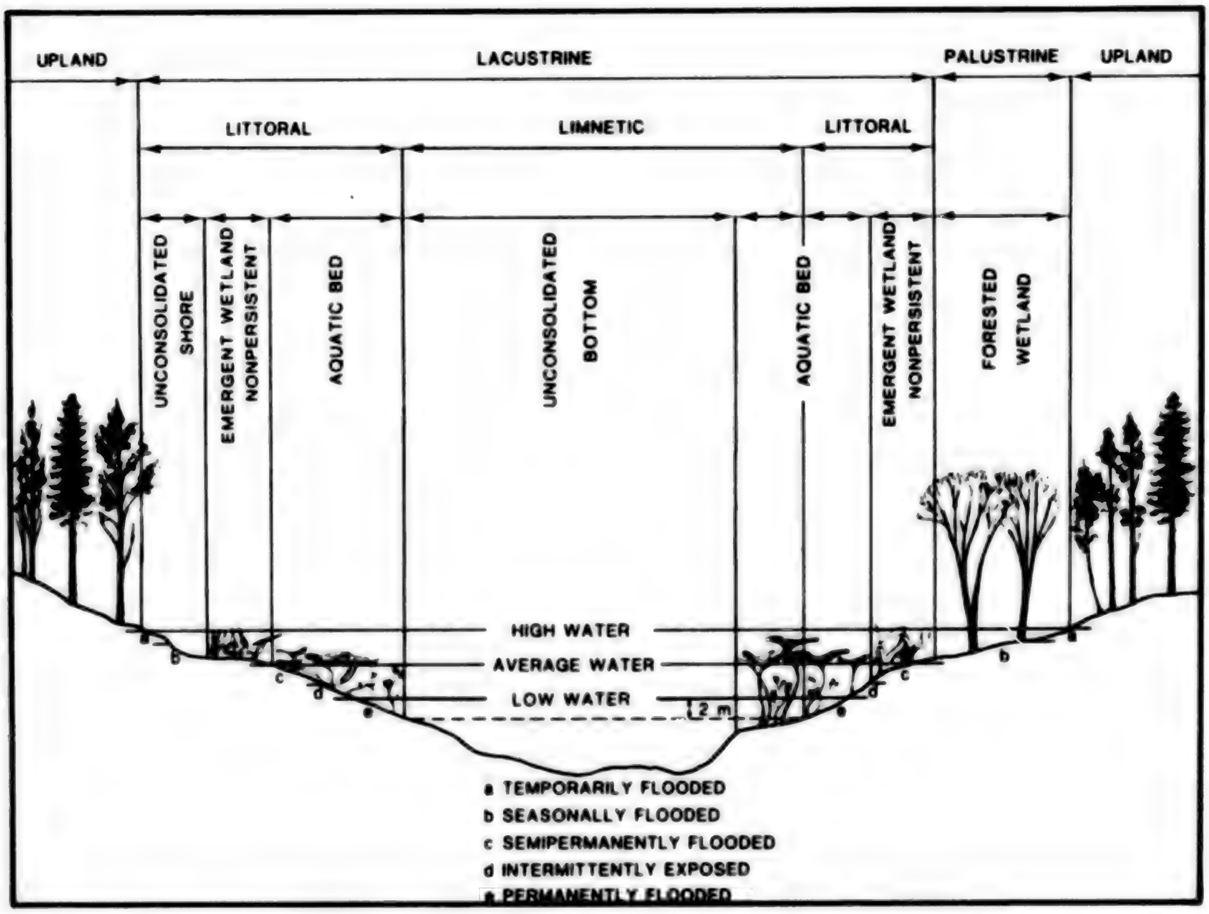


Figure 2-9. Distinguishing features and examples of habitats in the Lacustrine system (Cowardin et al. 1979).

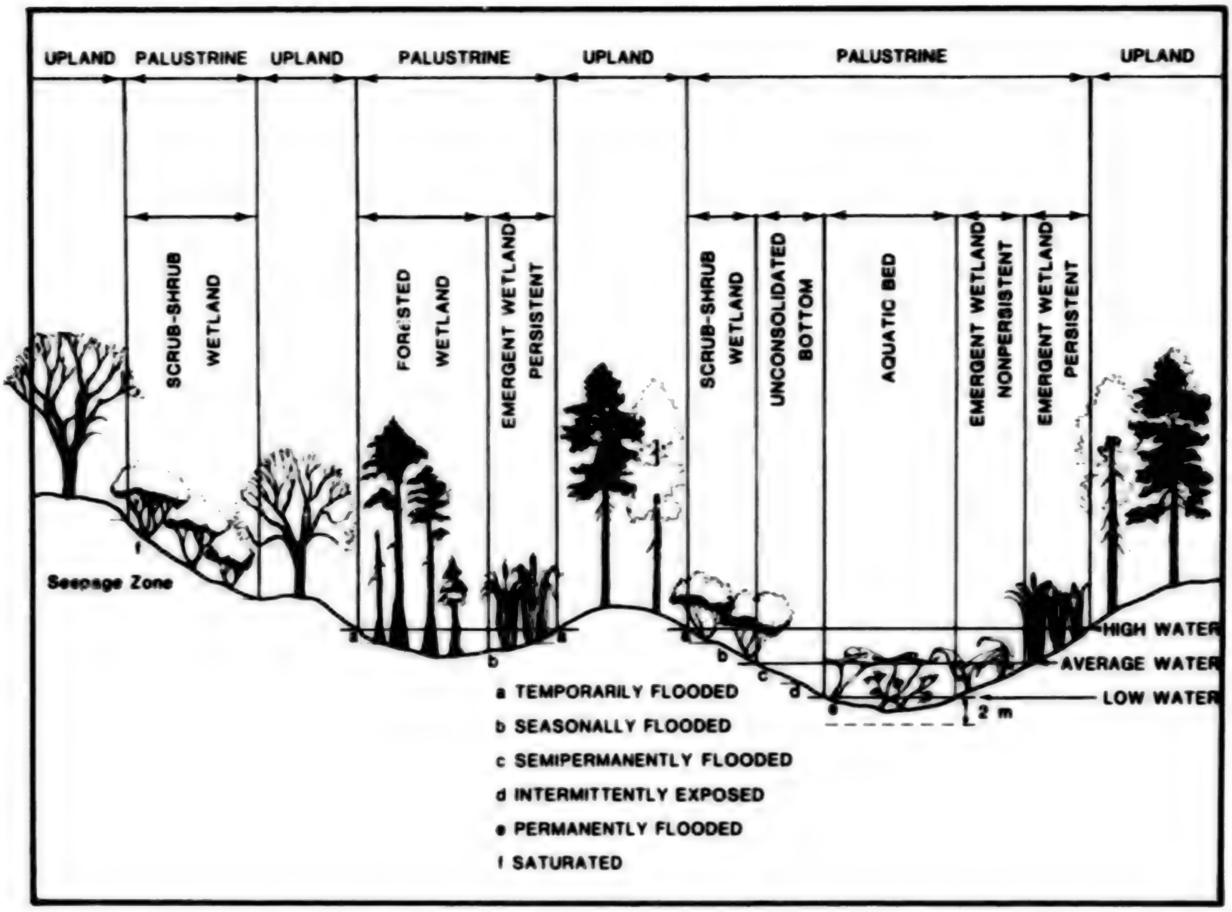


Figure 2-10. Distinguishing features and examples of habitats in the Palustrine system (Cowardin et al. 1979).

(3) *Subclass*: Mud (silt-clay)
(G) *Water Regime*: Intermittently Exposed
(h) *Special Modifier*: Diked/impounded.

A sample portion of an actual 1:24,000-scale NWI map (Figure 2-11) does not use all of the digits in Cowardin's system since this detailed level of classification was not required regionally. This playa appears to be modified as the open water is concentrated in a pit at one side.

Regional Land Use. Land use in the rural Southern Great Plains is essentially limited to cropland, irrigated cropland, and grazing land (Figure 2-12), as well as oil and gas production (Figure 2-13). Generally, the area north of the Canadian River Breaks is used mostly as cropland, except that grazing is more common to the west in Baca County, Colorado; Cimarron County, Oklahoma; and Dallam County, Texas. The area adjacent to the Canadian River is semiarid grazing land.

South of the Canadian River, the entire central portion is mostly cropland, with an interior central portion that is mostly irrigated. In Castro, Crosby, Deaf Smith, Floyd, Hale, Lamb, Lubbock, Parmer, and Swisher Counties in Texas, and in Curry County, New Mexico, croplands are irrigated extensively. The remaining areas in the study region to the south and west are mostly semiarid grazing land, except that Roosevelt County, New Mexico, has a large area used both for grazing and cropping.

Generally, the oil fields (Figure 2-13) are in the southern one-third of the study region where grazing and nonirrigated croplands predominate. There is a concentration of oil fields in Andrews and Midland Counties Texas, and Lea County, New Mexico. Gas fields are concentrated mostly in the northern one-third of the study region, primarily where dry farming is practiced.

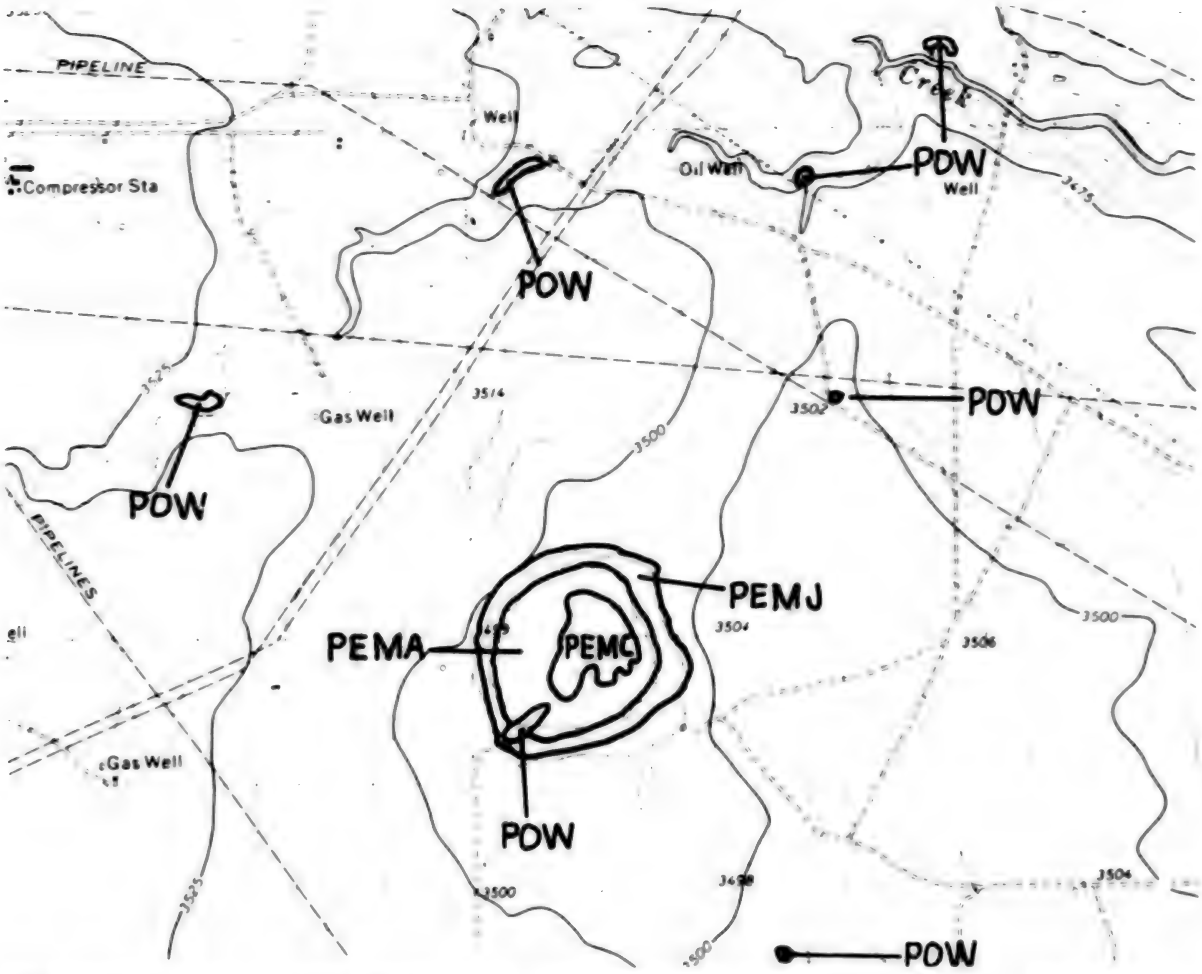
The distribution of crops in the study region is significant in evaluating wildlife habitat values (Figures 2-14 through 2-17). Corn, a heavy water user, is mainly concentrated in two Kansas counties—Gray and Haskell—and in five Texas counties—Castro, Deaf Smith, Hale, Lamb, and Parmer—where there is heavy irrigation (Figure 2-14). Only 22 out of 60 counties in the study region have more than 10,000 ac (4,050 ha) planted in corn. Grain sorghum (Figure 2-15) is cultivated more extensively than corn in the Southern Great Plains. Forty-four counties of 60 have more than 10,000 ac (4,050 ha) planted in sorghum, concentrating more in the northern dry farming district.

There is a pronounced increase in the acreage of wheat planted from south to north (Figure 2-16), concentrating north of the Canadian River Breaks. Forty-four of the 60 counties are planted in more than 10,000 ac (4,050 ha), and 29 of these have more than 50,000 ac (20,250 ha) planted. Cotton has almost the opposite distribution of wheat (Figure 2-17); the major concentration of cotton farms is in the more temperate southern half of the study region.

2.5 TOPOGRAPHY AND GEOHYDROLOGY

The topography of playas is related to soil texture. Playas are common in the three soil texture zones—coarse, medium, and fine—of the Llano Estacado or Southern High Plains (Figure 2-7), but they change in shape, size, and frequency according to soil texture. In general, the medium-texture zone has a high density of small, deep, round playas, and the fine-texture zone tends to have larger, shallower, and fewer playas (Allen et al. 1972; Lotspeich et al. 1971). However, data from Guthery and Bryant (In press) indicate that playas generally decrease in size north of the Canadian River Breaks and into Kansas, even though soils may be finer-textured.

The playa topography in an area of Lubbock County, Texas, illustrates the high density of small playas where sandier soils predominate (Figure 2-18). An area of Randall County, Texas, illustrates the larger, shallower playas of the fine-textured



Key to alphanumerics for large playa mapped and coded PEMC, PEMA, PEMJ, and POW: **Scale of 1:24,000**

P: Palustrine System
EM: Emergent Class
OW: Open Water Class
C: Seasonally Flooded
A: Temporarily Flooded
J: Intermittently Flooded

Figure 2-11. Portion of a sample National Wetland Inventory map showing a large playa near Amarillo, Texas, with alphanumeric classification (National Wetland Inventory, U.S. Fish and Wildlife Service).

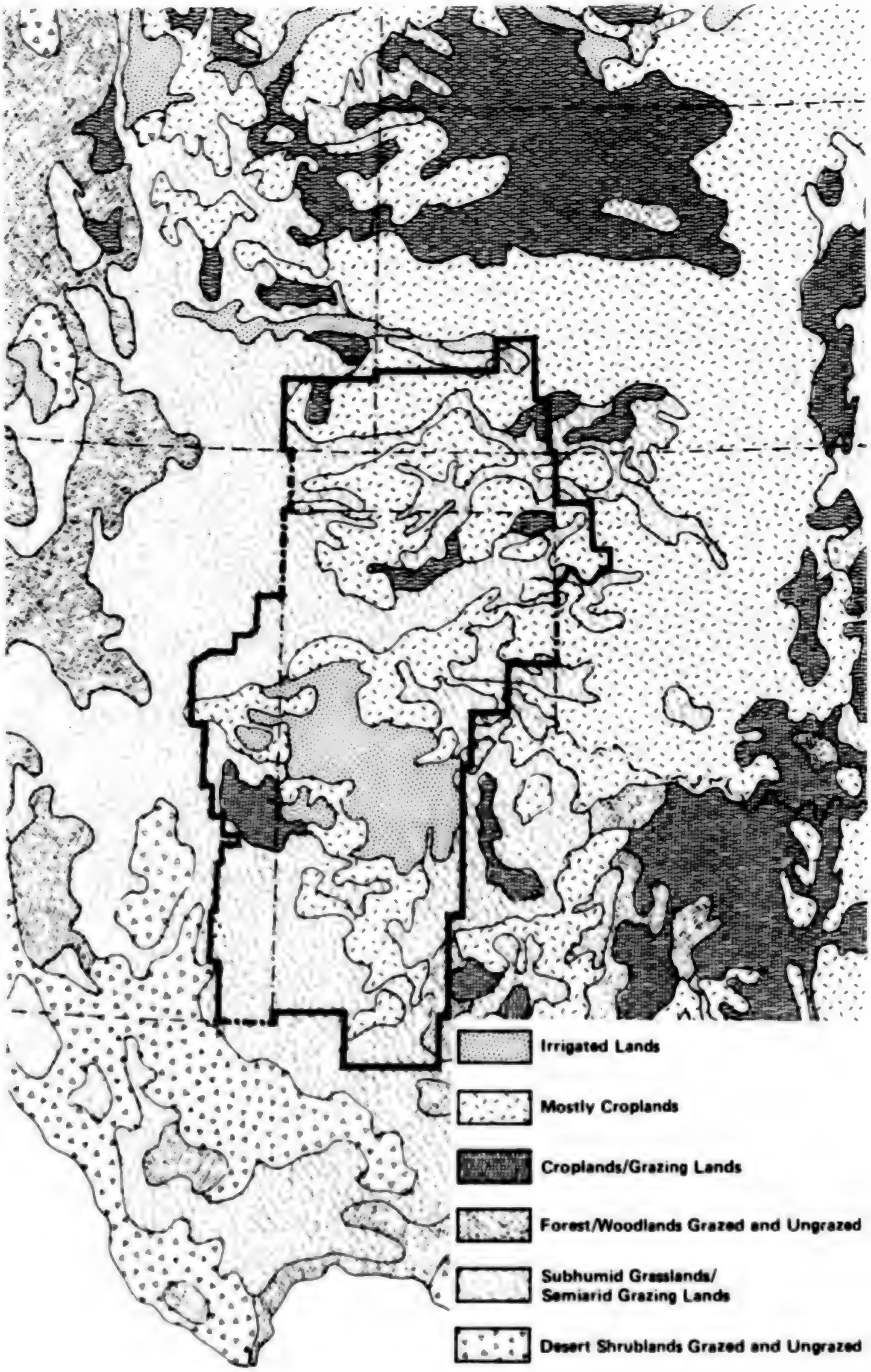


Figure 2-12. Major land uses in the region of the Southern Great Plains (U.S. Geological Survey 1970).

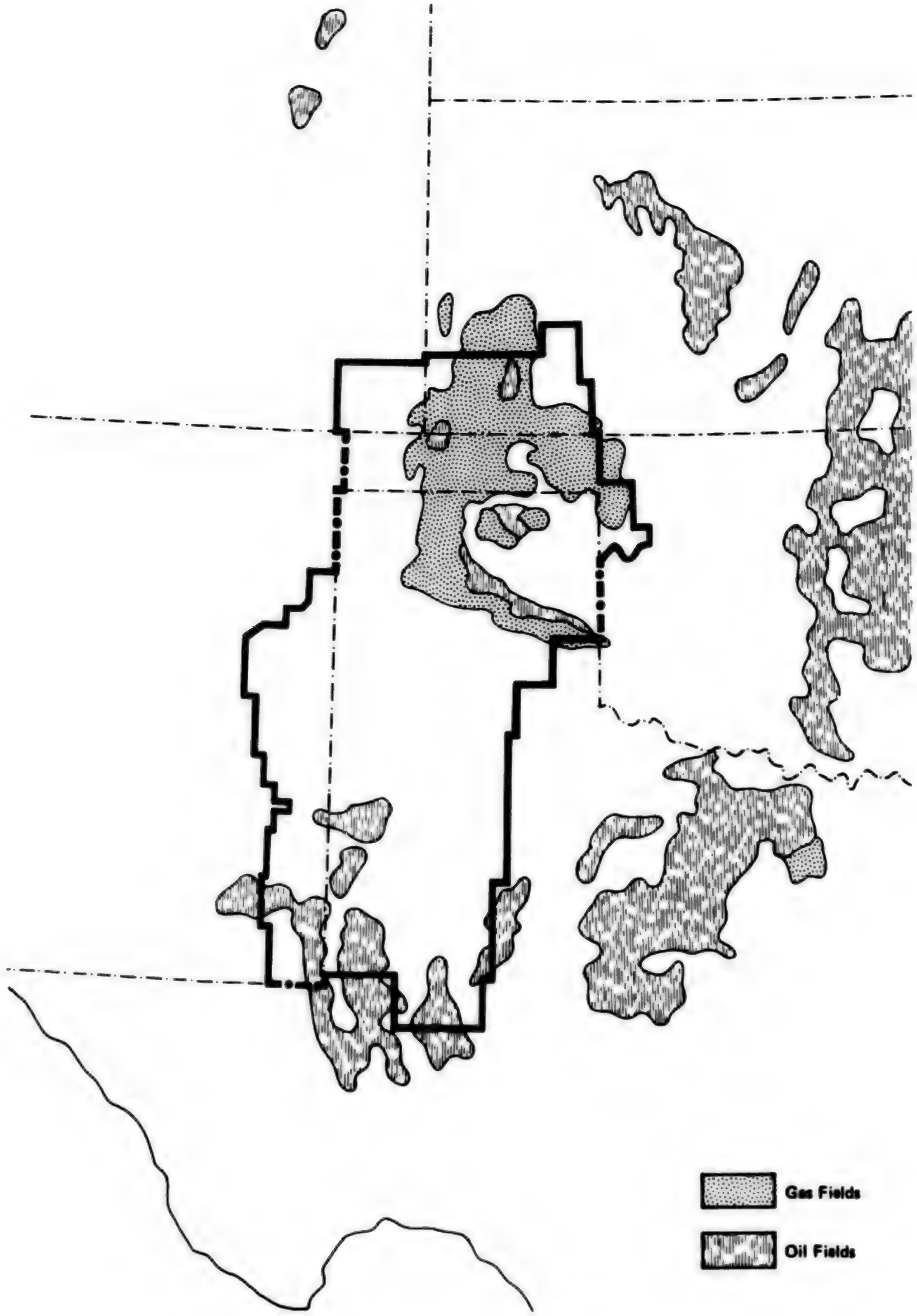


Figure 2-13. Distribution of major oil and gas fields in the region of the Southern Great Plains (U.S. Geological Survey 1970).

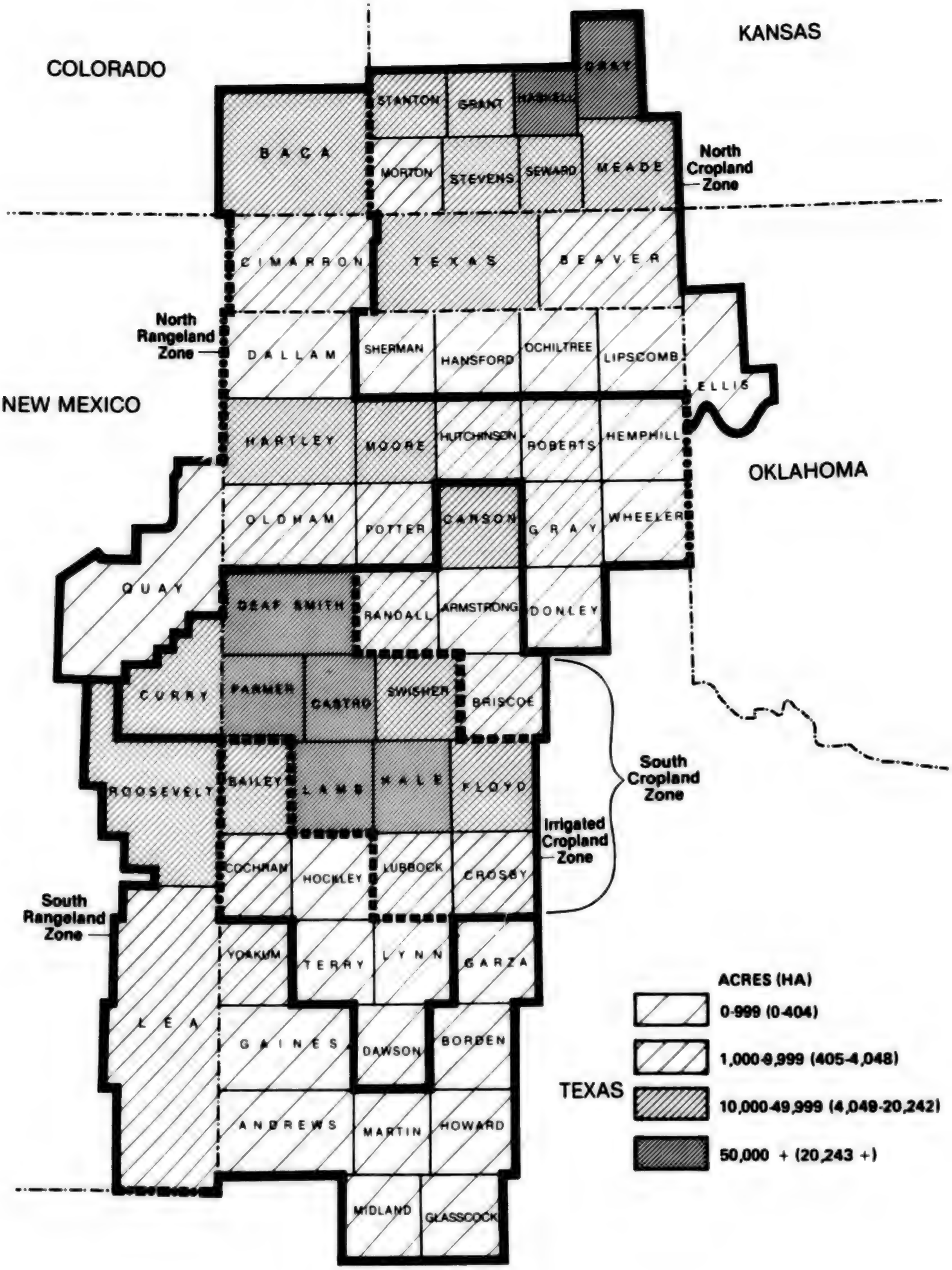


Figure 2-14. Acreage of corn harvested by counties within the study region (U.S. Department of Commerce 1978).

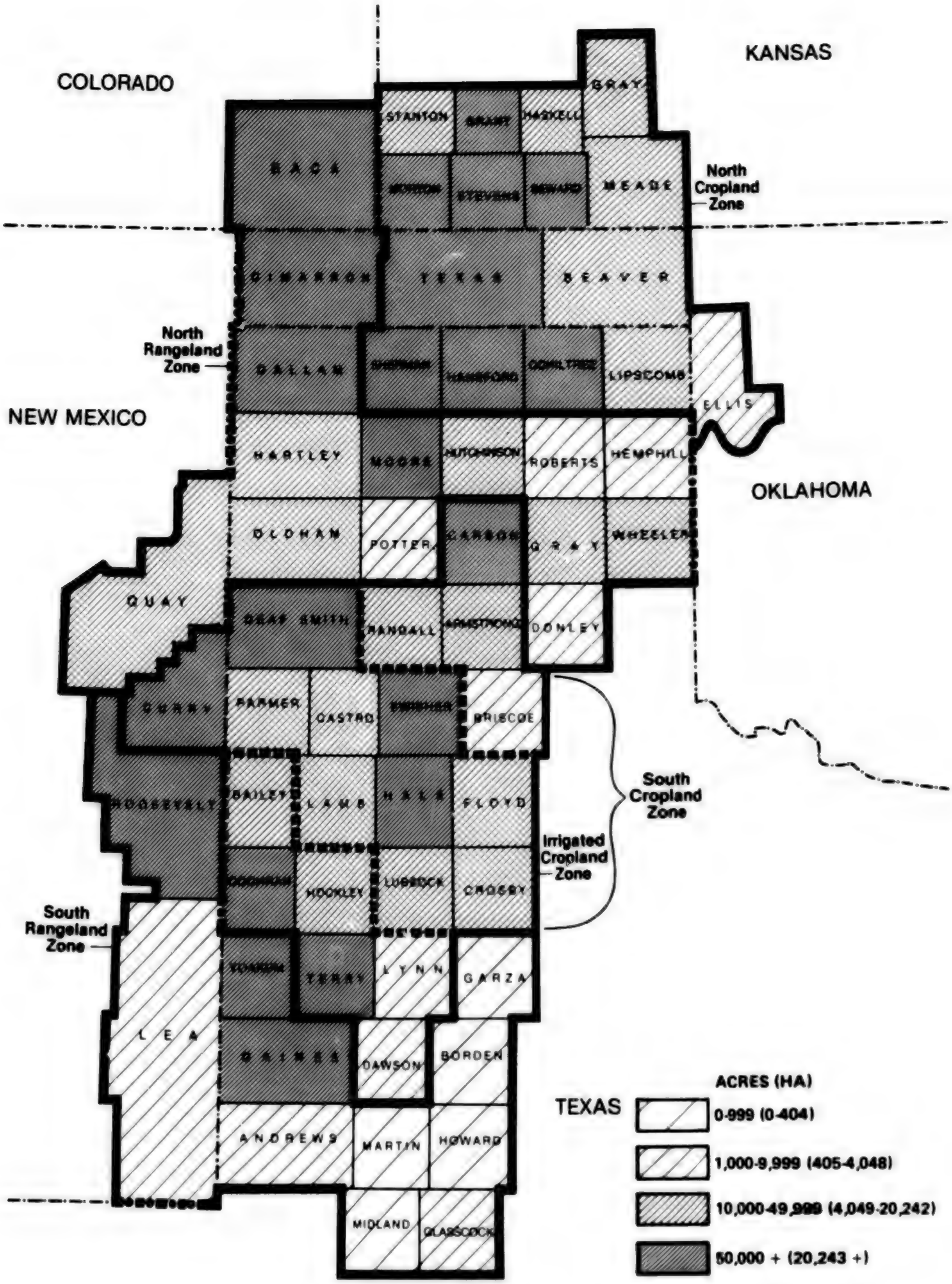


Figure 2-15. Acreage of sorghum harvested, by counties within the study region (U.S. Department of Commerce 1978).

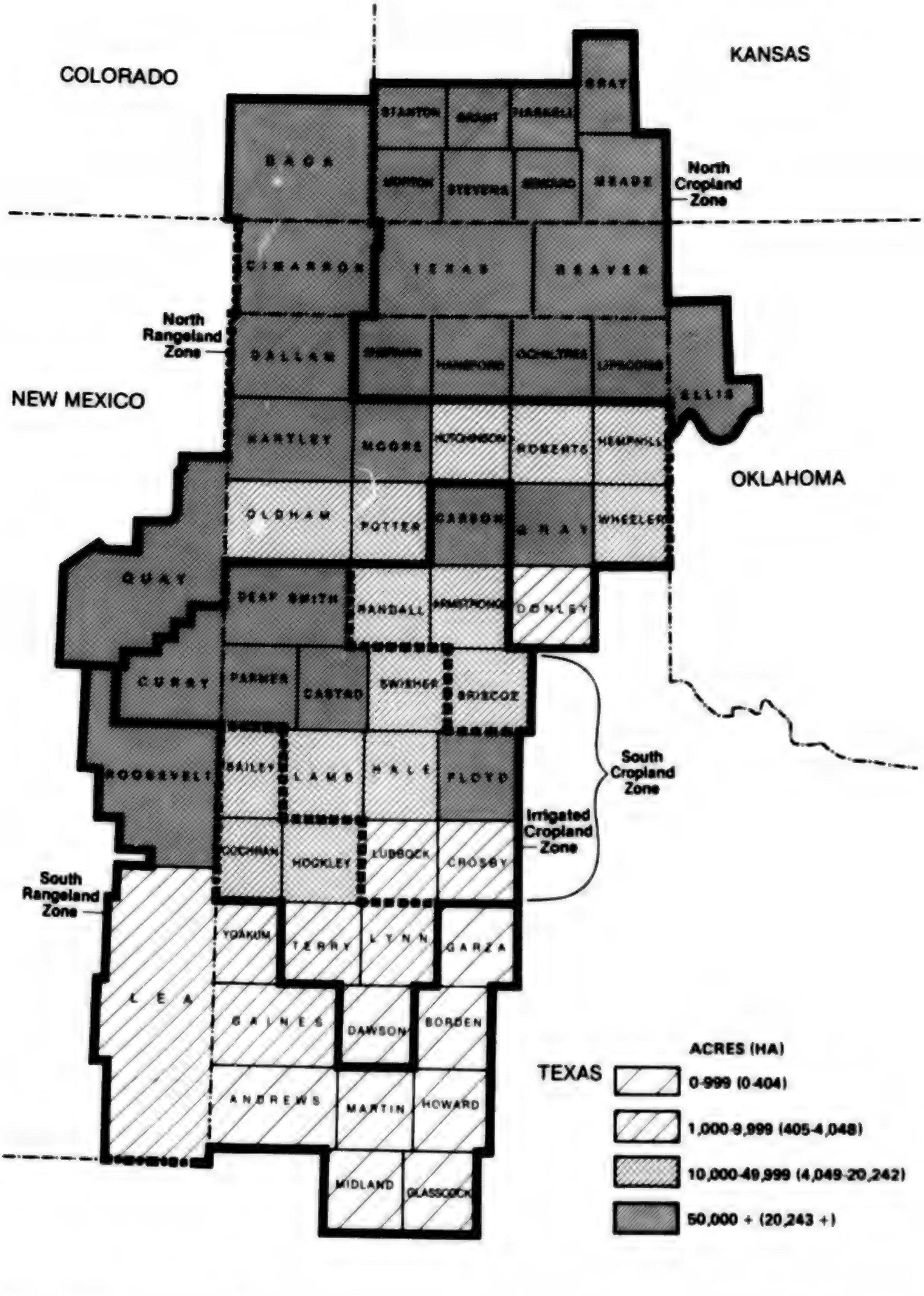


Figure 2-16. Acreage of wheat harvested, by counties within the study region (U.S. Department of Commerce 1978).

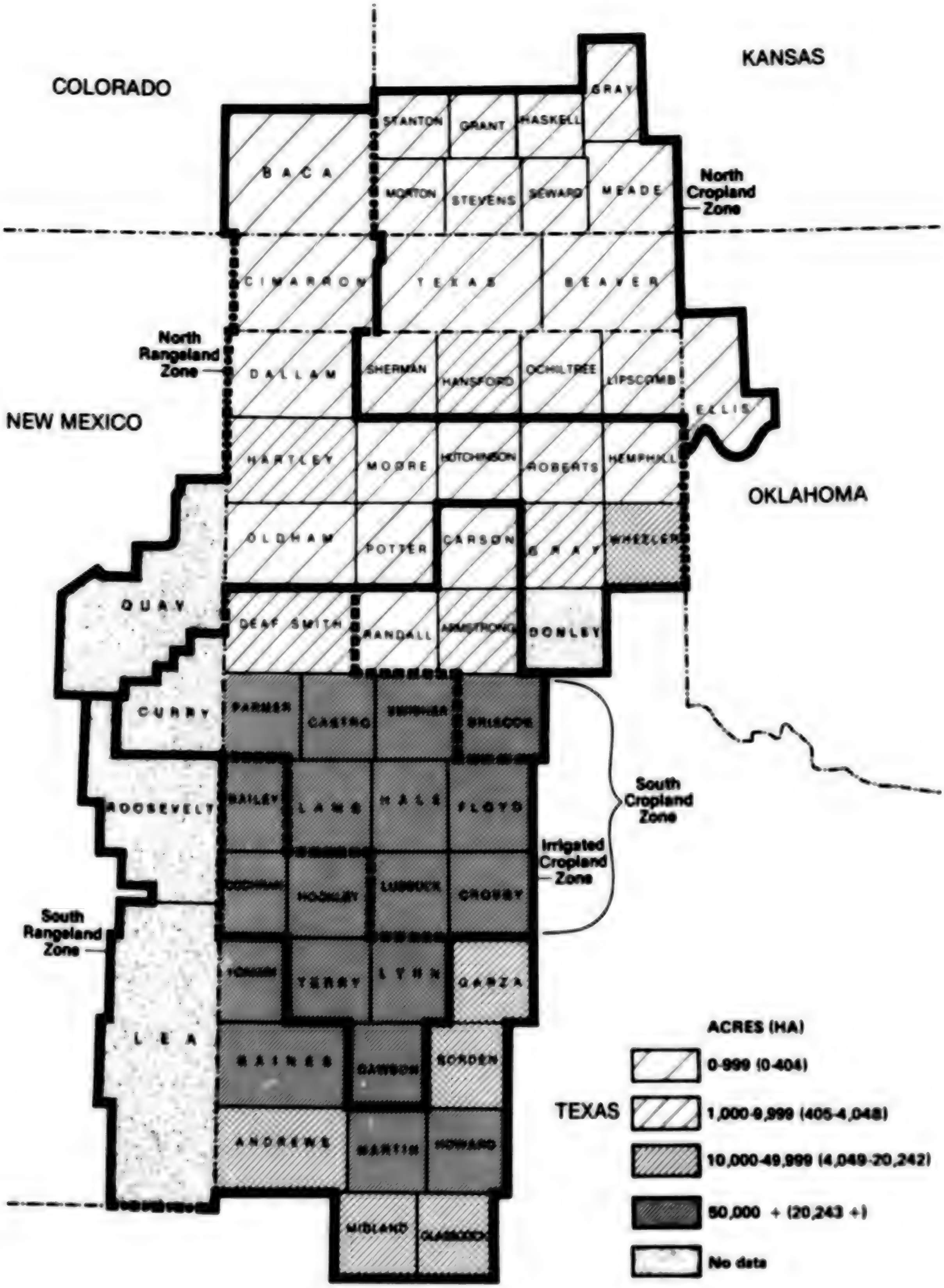
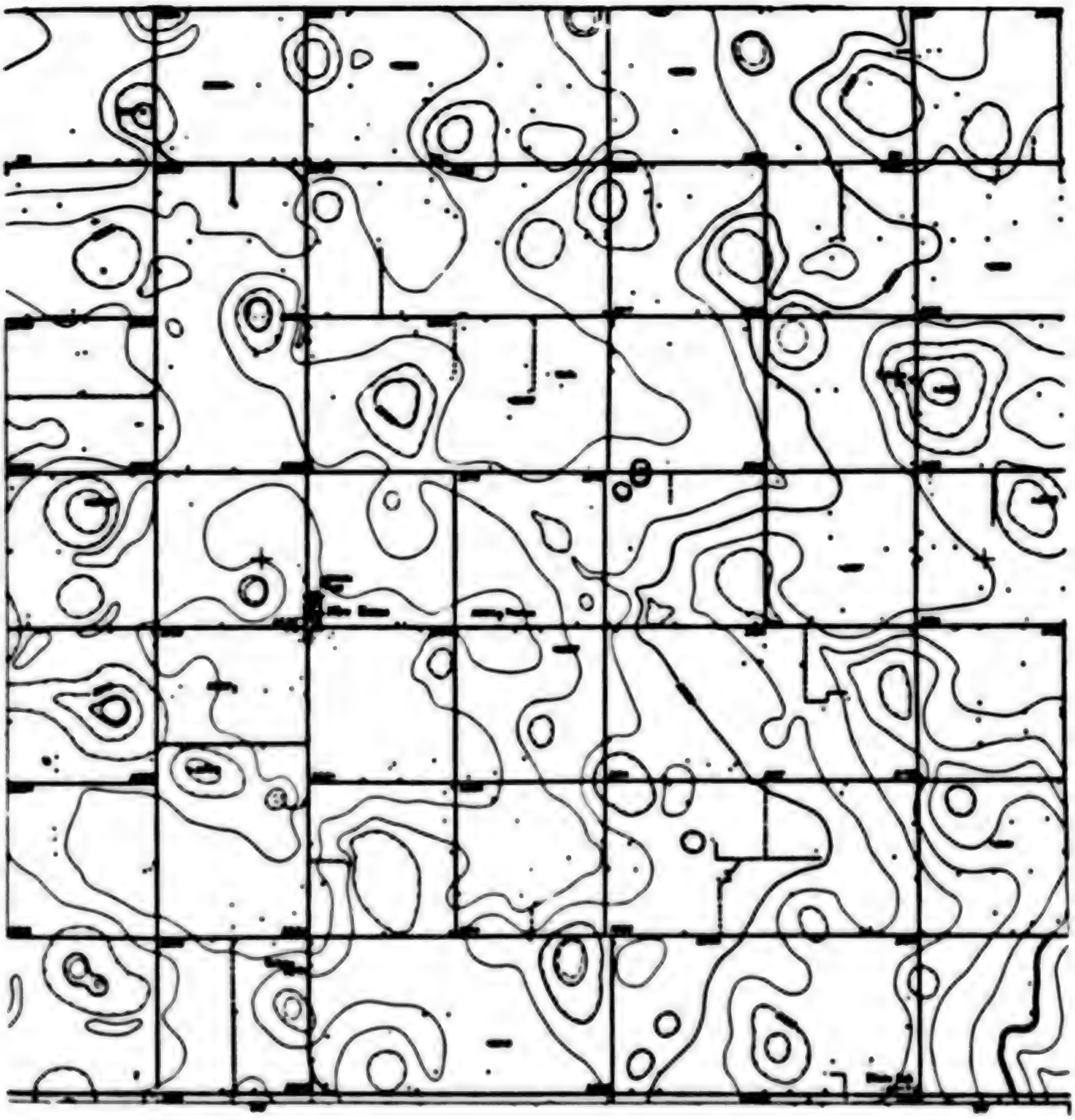


Figure 2-17. Acreage of cotton harvested, by counties within the study region (U.S. Department of Commerce 1978).



Contour interval of 10 ft (3 m)

Scale of 1:62,500

Figure 2-18. Typical topography of small, deep playas where medium-textured sandy loam soils predominate in the area south of Lubbock, Texas, in Lubbock County (Dvoracek 1981).

"hardlands" where silty clay loam is common (Figure 2-19). A common "hardland" playa may have a depth of 2 m and cover close to 150 ac (60 ha), as opposed to a medium-textured sandy loam playa about 2.5 m deep, but covering less than 40 ac (15 ha).

Some playa basins in the Southern Great Plains are larger and deeper than the majority; they are called "salt lakes" and are most common in Andrews, Gaines, Hockley, Lamb, and Terry Counties, Texas, in the south-central part of the study region, which has coarse soils. The salt playas usually are quite large, having up to several square miles (8 km^2) in surface area. They often receive water from "Ogallala seeps" or springs besides from precipitation. When the water table is low, these basins dry out, and a white salt crust forms on the surface (Allen et al. 1972).

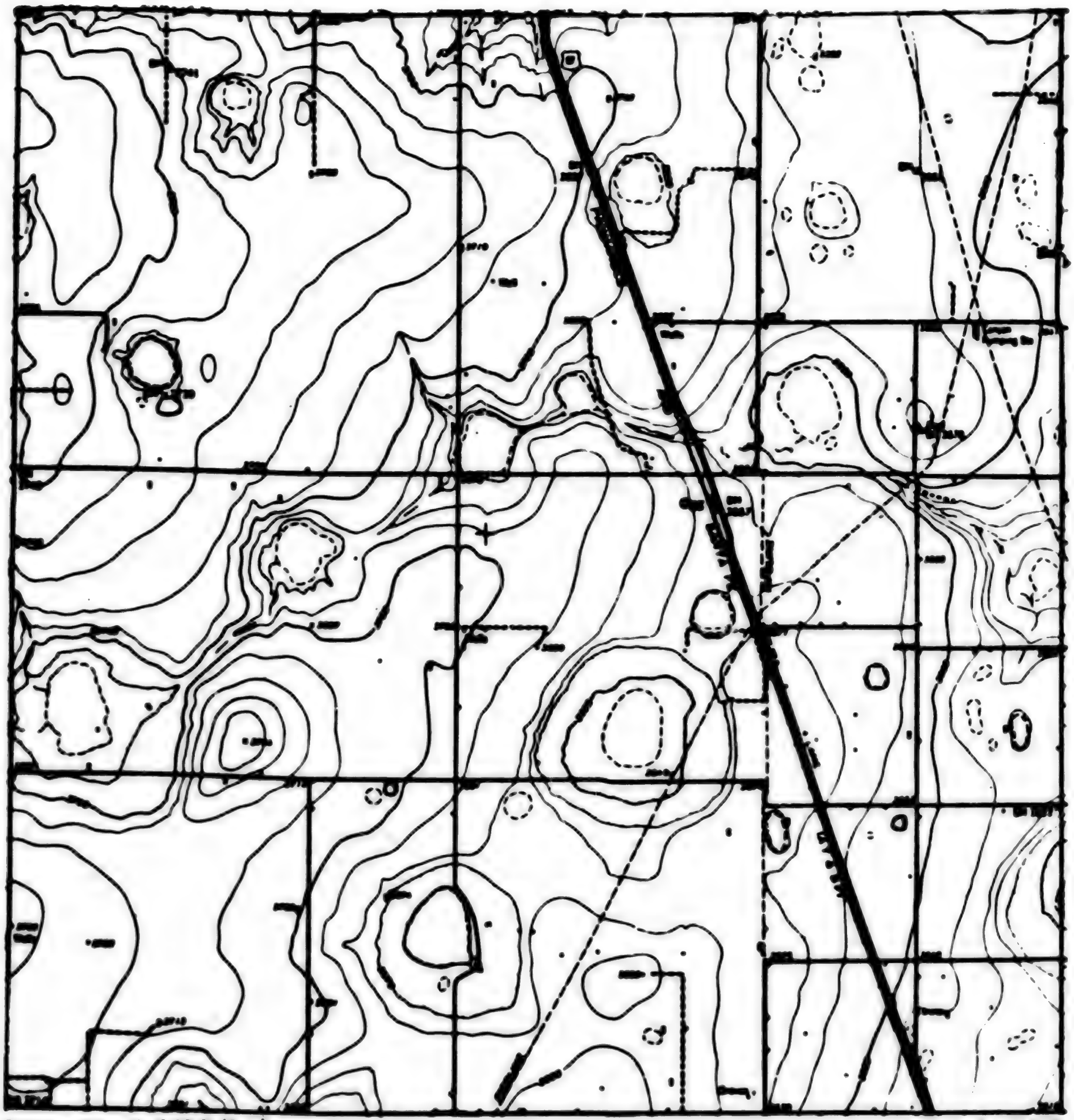
Regional Geohydrology. The Ogallala Aquifer was laid down as Pliocene sediments of wet gravel between 125 and 155 ft (38-47 m) thick. The Ogallala formation is a vast source of prehistoric water which extends from South Dakota through Nebraska, western Kansas, and the panhandle of Oklahoma into the Texas High Plains (Figure 1-1). It has served as a spur to development of the Southern Great Plains by providing its primary source of water, particularly for irrigation. Withdrawals from wells in the study region (Figure 2-20), primarily in the Irrigated Cropland Zone, have exceeded 5,500 mgd or 6.2 x 10^6 ac-ft (7.6 x 10^9 m^3) annually. Natural recharge of the Ogallala is only one-tenth to one-eighth of the withdrawals (Dvoracek and Black 1973), and the elevation of groundwater is steadily declining (Figure 2-21) (Templer 1978). Essentially, the Ogallala is "hydrologically isolated" (Dvoracek and Black 1973), and the utilization of this resource is a "mining operation" (Templer 1978).

Some natural recharge of the Ogallala Aquifer occurs through seepage from playa basins, depending on the soil type. Most water loss from playas is through evaporation, but studies conducted by Clyma and reported in Hauser (1968) indicated that the reduction in playa water volumes often exceeded the expected evaporation losses. The differences between the two quantities were determined to be the seepage losses. Clyma found that playa seepage in a fine-textured "hardland" (silty clay loam) soil was about 14% of the water impounded. Cronin (1961) reported a seepage rate of about 35% in a clay loam soil, while Reddell and Rayner (1962) indicated rates over 50% in a sandy loam soil. Apparently the higher rates occur only when playas are full, as water flooding the banks then overlies the more permeable sandy zone beyond the fairly impermeable clay substrate of the playa floor (Hauser 1968).

2.6 PLAYA NUMBERS, SIZES, AND DISTRIBUTION

Estimates of the numbers of playas in the Southern Great Plains usually have been made from U.S. Geological Survey topographic or Soil Conservation Service soil survey maps, and are actually estimates of playa *basins* that may contain water either permanently or seasonally. These estimates vary and have been as high as 37,000 (Schwiesow 1965), which is apparently an overestimate. Curtis and Beierman (1980) counted a total of 24,600 basins, with 20,000 in Texas; 2,000 in Kansas; 1,700 in New Mexico; 700 in Oklahoma; and 200 in Colorado. Guthery and Bryant (1982) counted 25,390 playas in 54 counties of the Southern Great Plains. A reasonable approximation would appear to be 25,000.

From Guthery et al. (1981), it is apparent that the numbers of playa basins change considerably among the zones of the study region. Most of the playa basins are clustered within the South Cropland Zone, and are particularly concentrated in the irrigated district (Irrigated Cropland Zone), which is central to the South Cropland Zone. Conversely, the area around the Canadian River Breaks (North Rangeland Zone) has comparatively few playas. The



Contour interval of 10 ft (3 m)

Scale of 1:62,500

Figure 2-19. Typical topography of large, shallow playas where fine-textured silty clay loam soils predominate in the area south of Amarillo, Texas, in Randall County (Dvoracek 1981).

concentrations within the North Cropland and South Rangeland Zones are intermediate between those within the North Rangeland (low) and South Cropland (high) Zones.

The sizes of playa basins, as well as the numbers, change according to zones within the study region. The smallest basins are found in the medium-texture soil region where the largest playas do not exceed 150 surface acres or 60 hectares (Dvoracek and Black 1973). In the fine-texture soil region (South and North Cropland Zones), some basins exceed 600 ac (240 ha). Generally, the medium- to coarse-texture soil districts (primarily South Rangeland) have a greater number of smaller playas; the fine-texture districts (particularly South Cropland) have fewer and larger playas, although Guthery and Bryant (In press) found a decrease in playa size north of the Canadian River Breaks into Kansas (North Cropland Zone). On the whole,

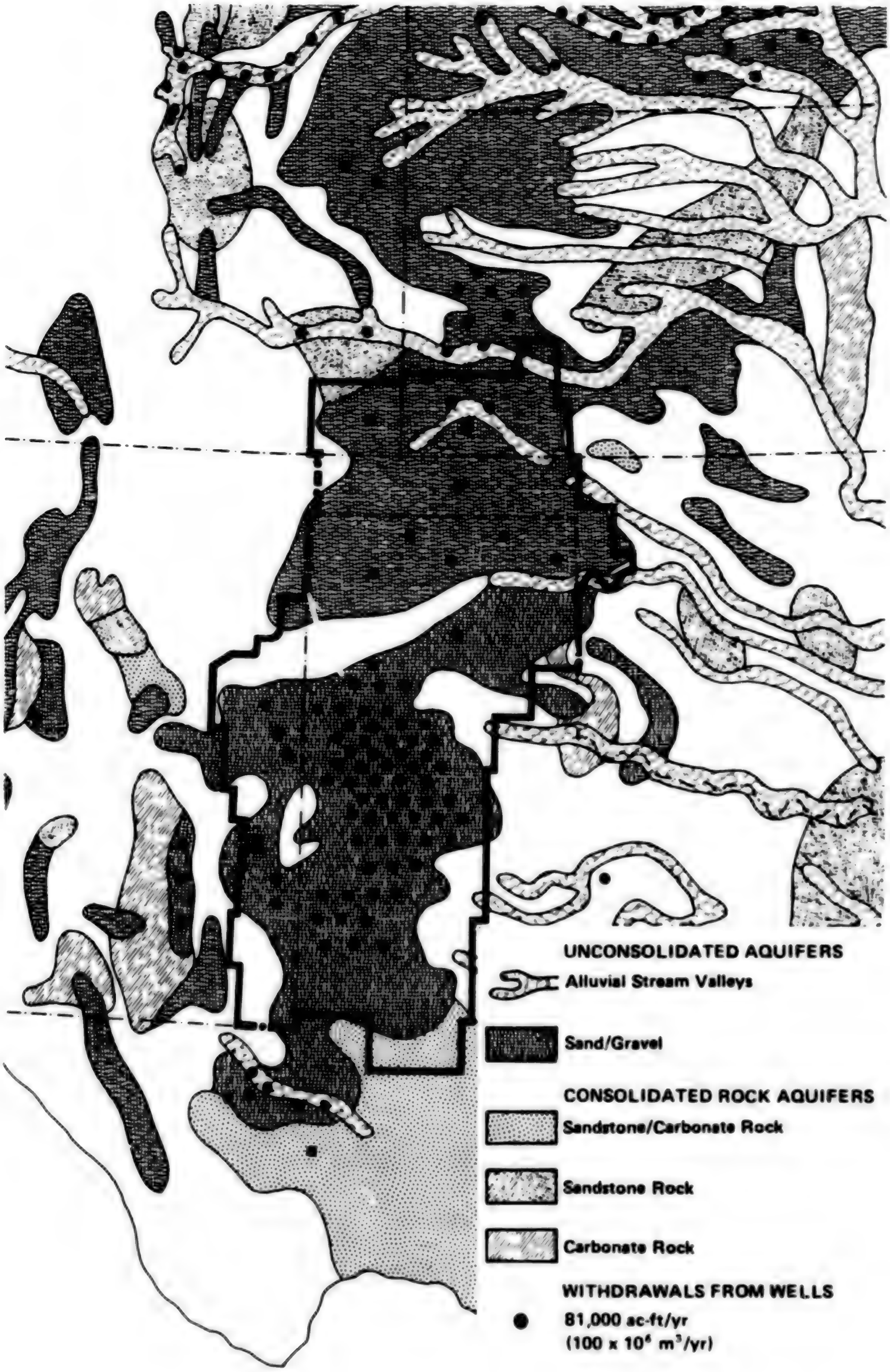


Figure 2-20. Productive aquifers and withdrawals from wells in the region of the Southern Great Plains (U.S. Geological Survey 1970).

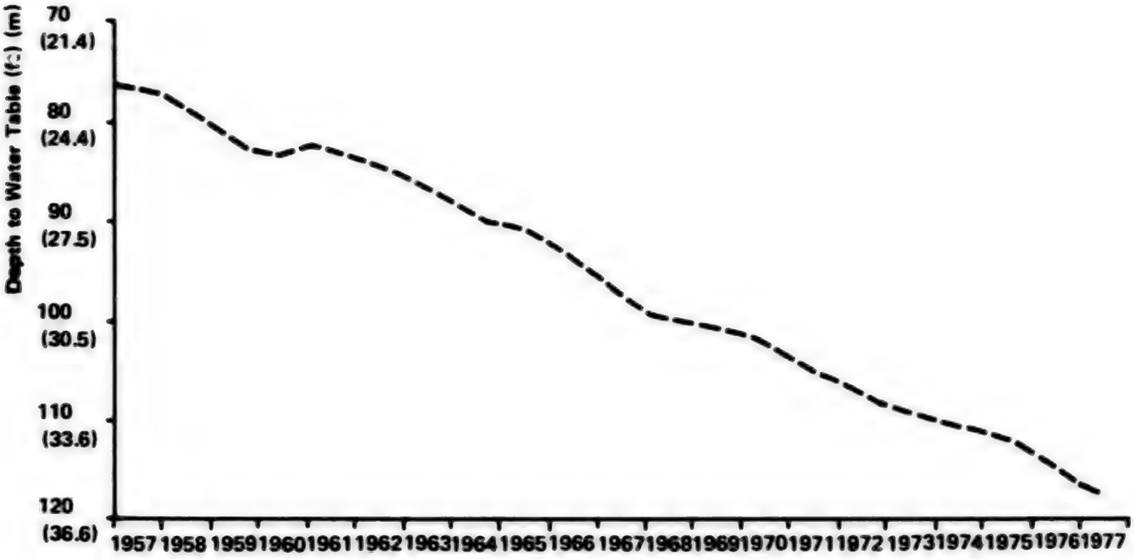


Figure 2-21. Hydrograph of an observation well on the Texas High Plains (Hale County), illustrating the gradual decline in Ogallala Aquifer water elevation (Templer 1978).

as playa sizes increase, total numbers decrease as does the proportion with medium-texture soils (Figure 2-22).

The overall surface density of playa basins varies by study region zones (Figure 2-1). The greatest mean density is 19 ac/mi^2 (30 ha/km^2) in the Irrigated Cropland Zone. The mean surface densities for the South and North Cropland Zones are 9.5 and 6.4 ac/mi^2 (1.5 and 1.0 ha/km^2), respectively. The North and South Rangeland Zones have the lowest mean surface densities–3.0 and 2.9 ac/mi^2 (0.5 ha/mi^2), respectively.

Playa Water Surface Distribution. The preceding discussion on playa basin distribution in mean surface density does not account for the differences in playa *water surface* among the zones of the study region. The following discussion compares the approximate mean *water* surface in each zone for both a wet and dry season. The data were gathered by LANDSAT imagery and processed by the Remote Sensing and Engineering Physics Section of the Bureau of Reclamation's Engineering and Research Center (Denver Federal Center) in conjunction with the Bureau's Playa Inventory. Most of the wet-season LANDSAT scenes were recorded during September and October 1974; most dry-season scenes are dated in April of 1978.

There are greater wet-season differences in mean surface water density between north and south than between the Rangeland and Cropland Zones (Figure 2-23). Both North Rangeland and North Cropland Zones have a mean water surface per square mile of less than half an acre (0.2 ha/km^2) during the wet season. This is a rather minimal amount of water to support wildlife restricted to aquatic habitat, especially in a wet season. At the other extreme, the Irrigated Cropland Zone has a wet-season mean water surface density of 2.2 ac/mi^2 (0.9 ha/km^2); greater availability of playa water surface in this district reflects the supply of irrigation tailwater, which more than offsets lower precipitation than to the north. The South Cropland Zone has a mean water surface density of 1.5 ac/mi^2 (0.6 ha/km^2); the South Rangeland figure is 0.9 ac/mi^2 (0.4 ha/km^2), which may suggest that, although the basins in this zone are relatively small, they may afford greater water availability than previously realized.

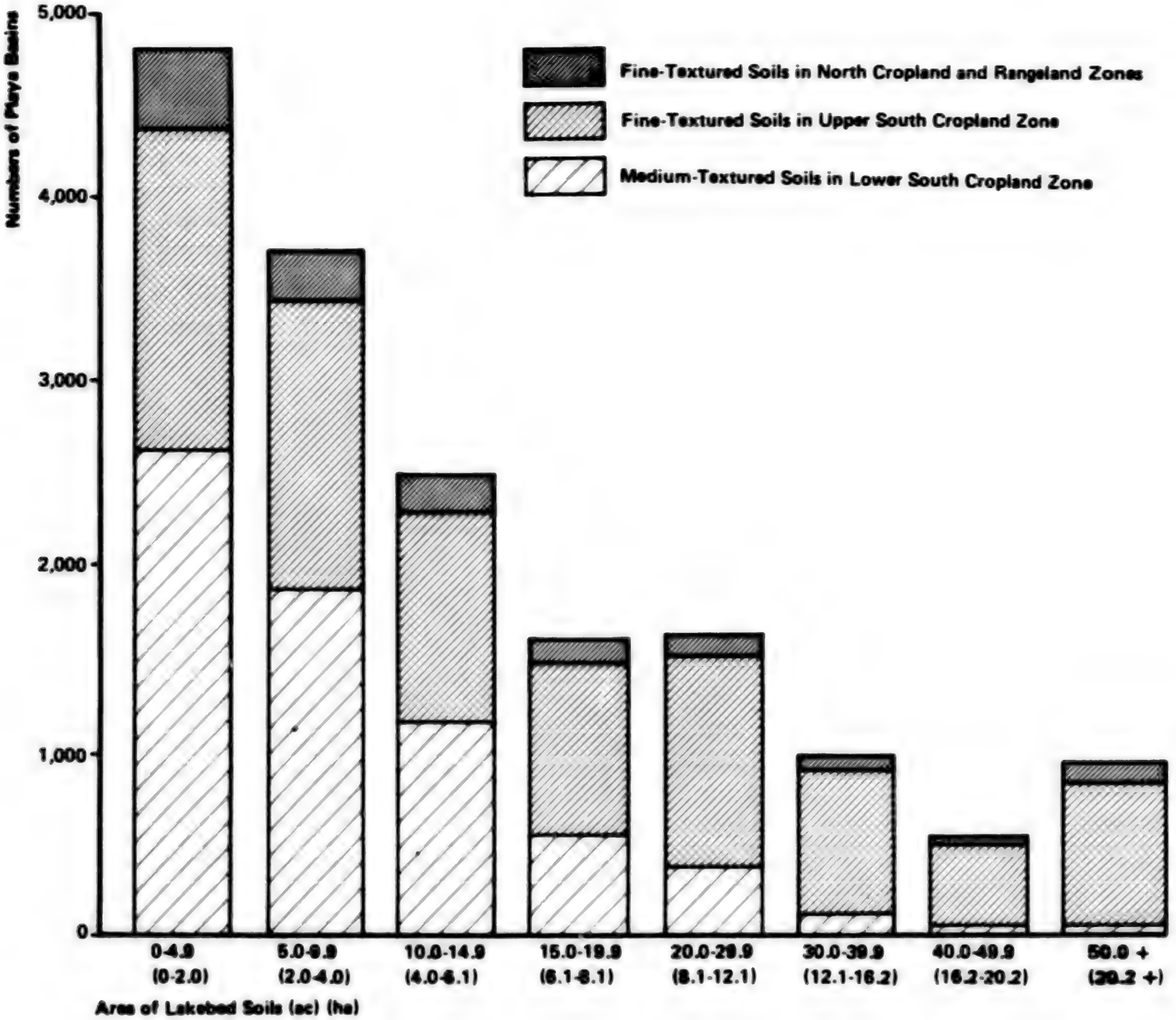


Figure 2-22. Numbers of playa basins by size classes and soil texture areas of the Texas High Plains (after Grubb, Parks and Sciple 1968).

The dry season data, although having incomplete coverage of the north and south limits of the study region, indicate that the main water availability in playas remains in the Irrigated Cropland Zone, but it is extremely low (Figure 2-24). The mean water surface density in this zone during a dry season is 0.1 to 0.2 ac/mi^2 (0.04-0.08 ha/km^2); the surrounding South Cropland Zone has a density between 0.05 and 0.1 ac/mi^2 (0.02-0.04 ha/km^2). Both the northern and southern parts of the study region can become extremely dry—less than 0.05 ac/mi^2 (0.02 ha/km^2) of water surface. Generally, in a dry season, most playas dry up and only a very minimal amount of water remains in the South Cropland and Irrigated Cropland Zones.

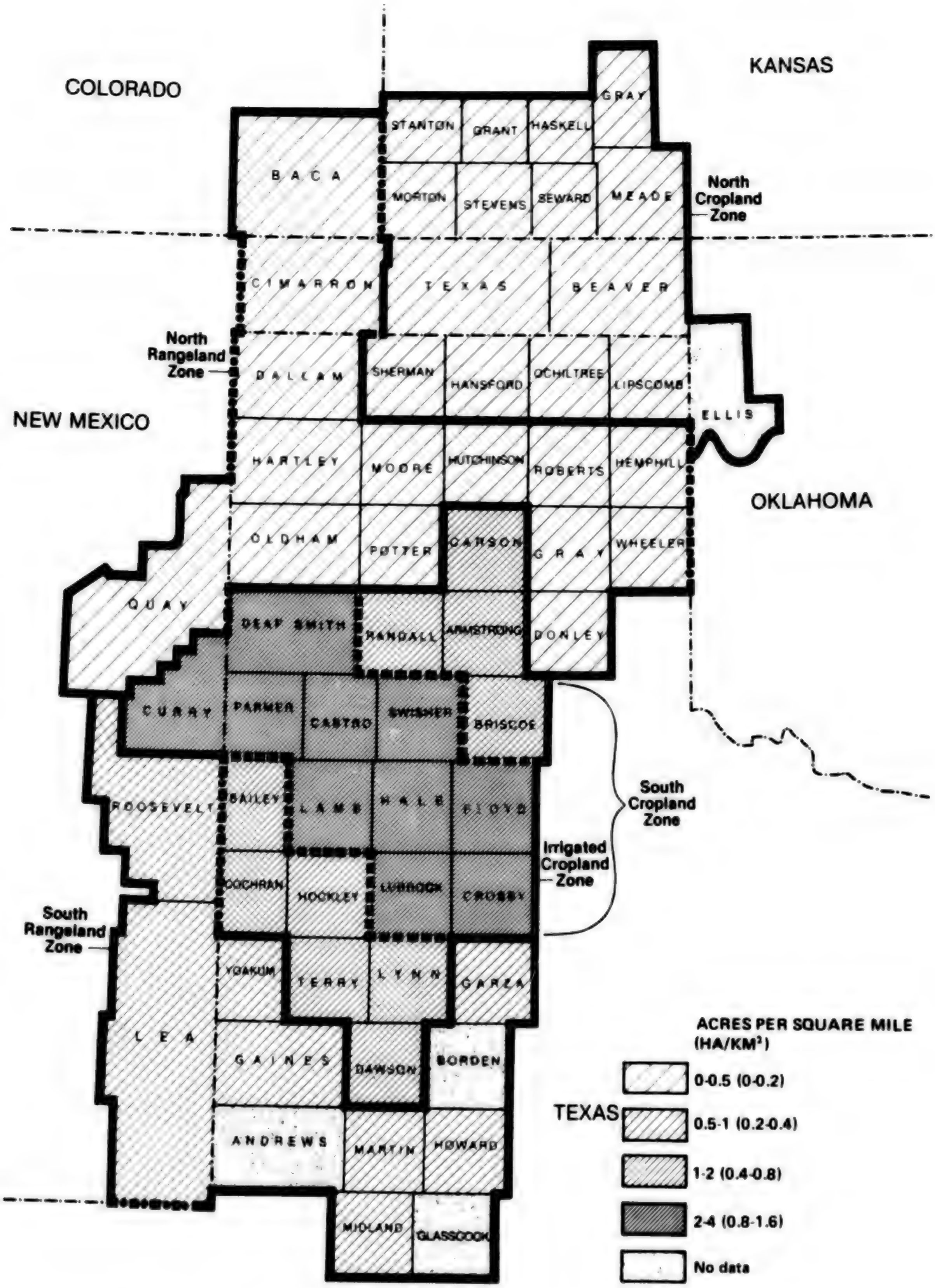


Figure 2-23. Average wet season playa water surface density, by zones of the study region (U.S. Bureau of Reclamation Playa Inventory 1982).

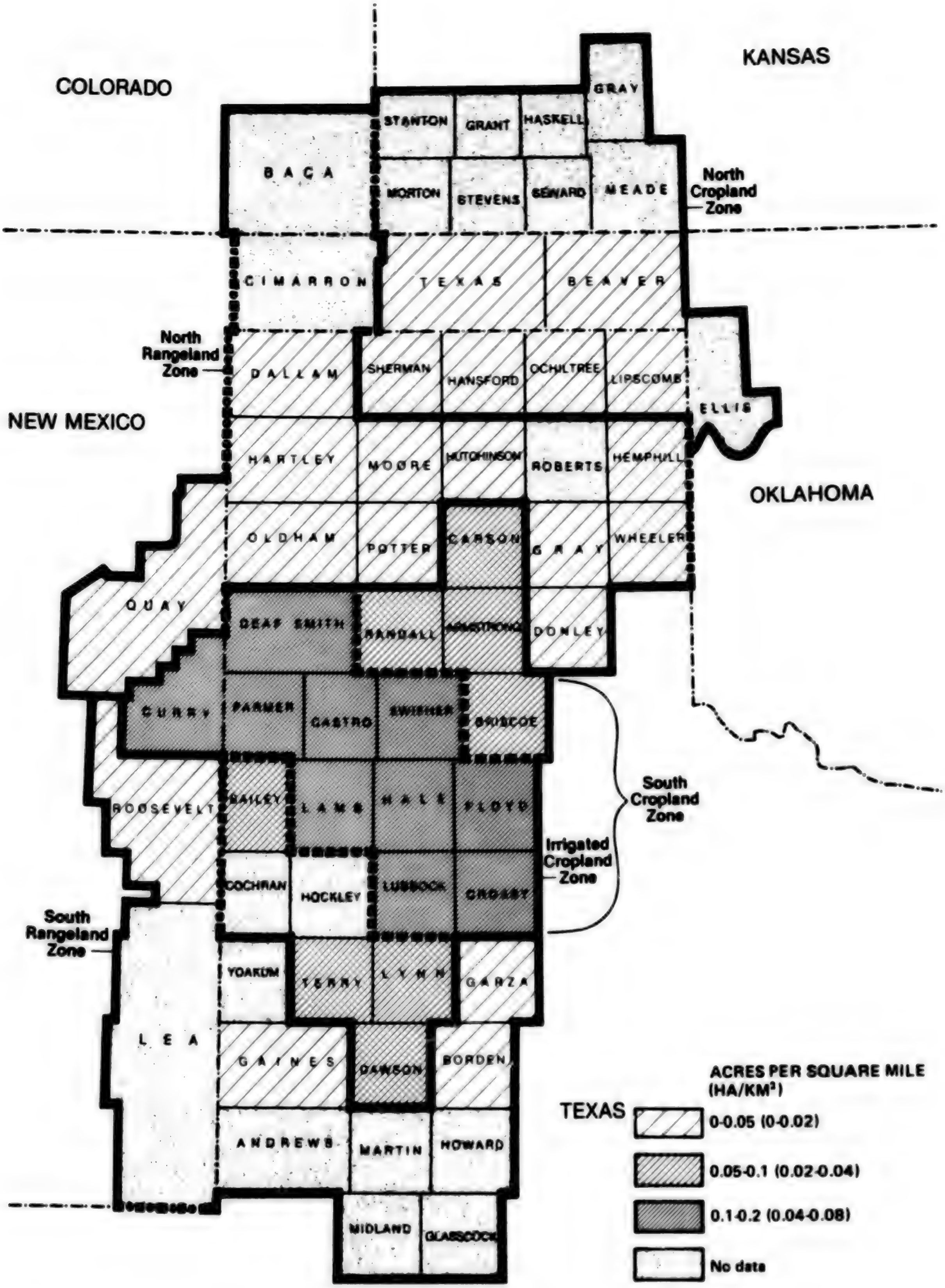


Figure 2-24. Average dry season playa water surface density, by zones of the study region (U.S. Bureau of Reclamation Playa Inventory 1982).

3.0 PLAYA BASIN ENVIRONMENT

Surface soils of playa basins are generally clays that form a highly impermeable seal and increase their water-holding capacity. Soil texture and percolation vary within the playa region; fine-textured soils near the center of the region provide maximum water retention. The hydrology of playas involves rapid accumulation of natural runoff during late spring, gradually subsiding by evaporation and seepage through the summer except where basins have been excavated to concentrate water. Annual precipitation and runoff can vary in the extreme. Playa water chemistry and quality in unmodified freshwater playas is generally uniform and highly suitable for wildlife as well as irrigation purposes. Some contamination from agricultural chemicals, cattle feedlot runoff, sewage effluents, and waste oil and brine has occurred.

3.1 PLAYA BASIN SOILS

Playa basin soils are predominately clay and strikingly similar regardless of location within the Southern Great Plains, reflecting similar formative processes. These soils may be associated with one of several soil series with only subtle differences exhibited within the textures of the soil separates. Economic, historical and wildlife values are represented in these playa basin soils.

Playa basins are typically defined as clayey-soil-surfaced depressions, interspersed among the lighter-textured regional soils. The playa soils are of the *Vertisol* order and may be listed as Randall, Lipan, or Ness clays, Stegall silty clay loams, Lofton clay loams, or may be uncharacterized with only the associated upland soils classified (Guthery et al. 1981; Curtis and Beierman 1980; Buol, Hole and McCracken 1973). The Randall soil series is the most frequently observed (Figure 3-1). The various playa and associated soil classifications from the five zones of the Southern Great Plains study region have been synopsized (Table 3-1). Also, the distribution of common playa basin soil types within the five-state region has been estimated (Table 3-2).

Characteristics of Playa Basin Soils. Soils of playa basins are clearly distinguishable compared to surrounding upland soils because of their contrasting darker color (Reed 1930). Compared to the more permeable soils occupying slopes and surrounding land, playa bottoms have a very slowly permeable clay and are poorly drained, resulting in a high water-holding capacity and periodic inundation (Bruns 1974). The surface horizon of various playa basin soils has been characterized (Table 3-3). These soils tend to reflect the textural and mineralogical influence of the associated upland soils in the silt/sand ratio, but bear little relation to the upland soil clay fraction (Allen et al. 1972). Playa silts are predominately quartz, have a considerable amount of feldspar, and lesser amounts of both potash and plagioclase. The clay component of playa basin soils usually exceeds 50%. The most common clay mineral is montmorillonite, although considerable illite and lesser quantities of kaolinite may be present.

Playa surface soils are generally neutral and have low organic carbon and salt concentrations. The underlying strata of playa basins are highly variable from playa to playa, ranging from heavy clays to fine sandy loams having marked dissimilarities in mineralogic and chemical properties. The particle size distributions of playa soils sampled from the three broad soil textural regions of the Llano Estacado (Southern High Plains) have been depicted (Figure 3-2).

The Randall and other playa clays are formed from alternate wetting and drying in the reworked sediments of the surrounding Aeolian (wind-deposited) mantle (Bruns 1974), clearly defining the area of hydric (water) influence (Guthery et al. 1981). Playa subsoils exhibit marked evidence of mixing,

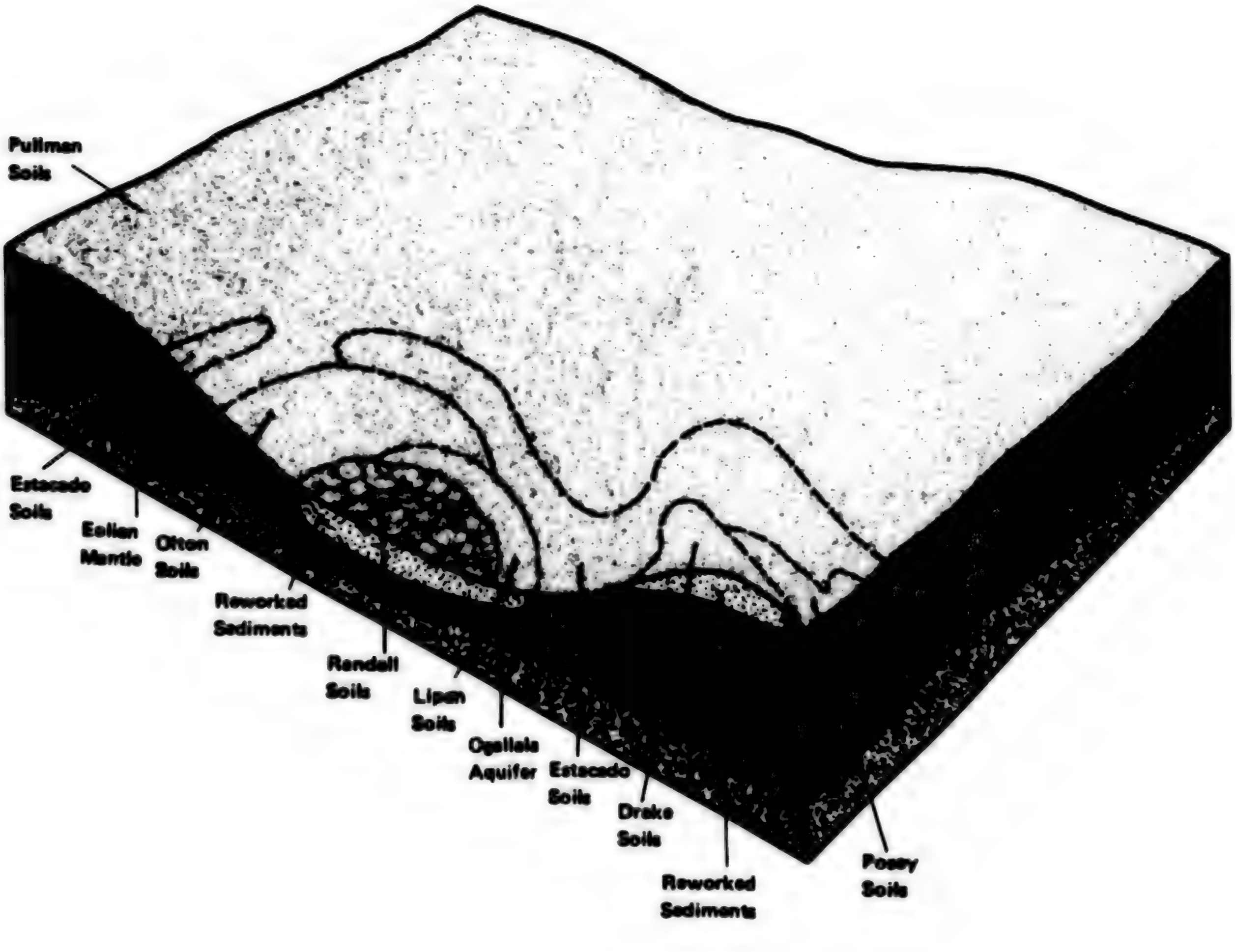


Figure 3-1. Generalized representation of Randall and associated soils within a playa landscape (Bruns 1974).

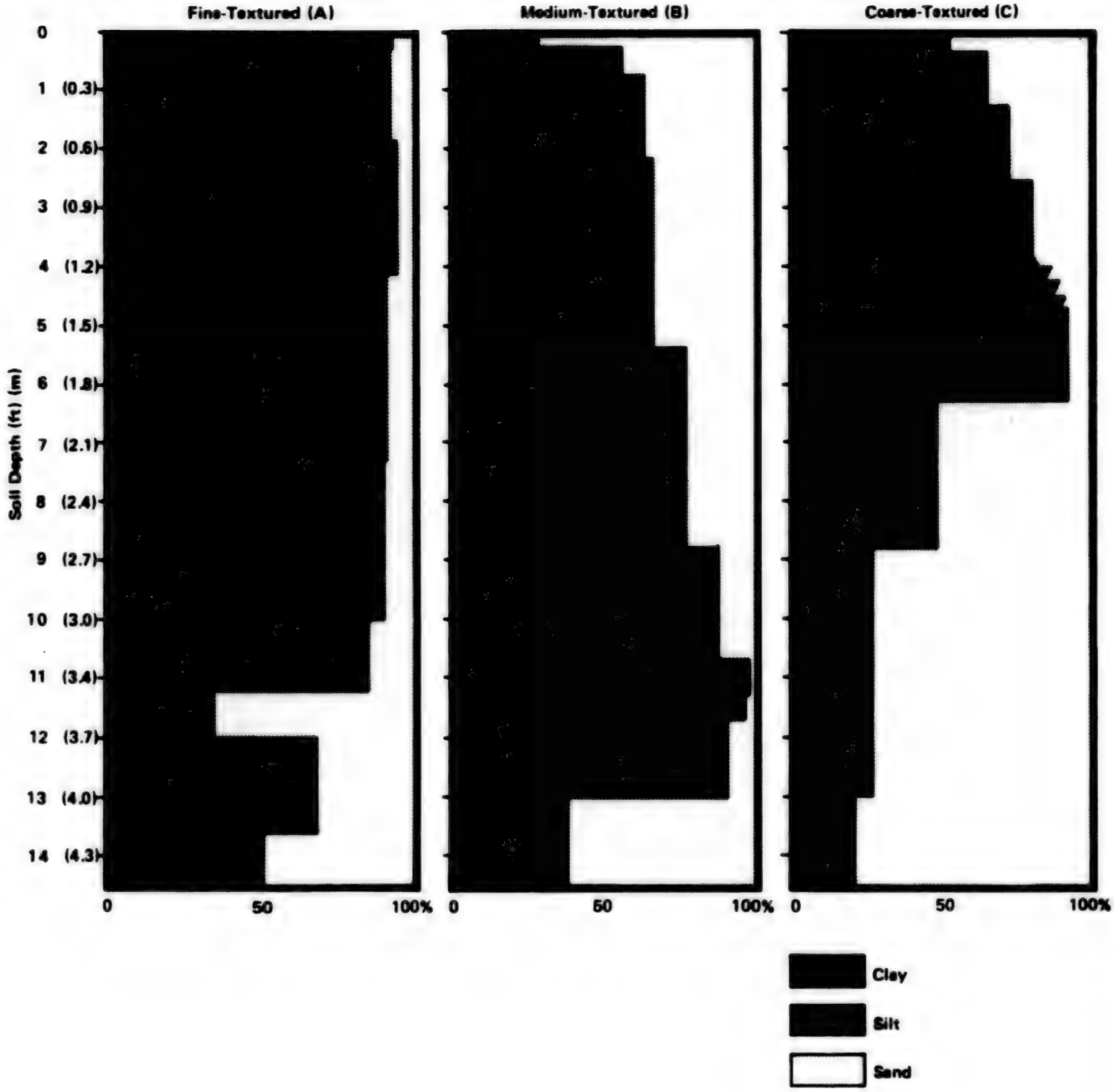


Figure 3-2. Particle size distribution of playa basin soils in three soil texture zones of the Llano Estacado (Southern High Plains): (A) Randall 1, (B) Randall 2, and (C) Lipan soils from the Pullman, Amarillo, and Arvana soil series, respectively (Allen et al. 1972).

Table 3-1. Playa and associated soil classifications of the Southern Great Plains, by zones of the study region (various sources).

Zone	County, State	Dominant Soil Order	Associated Upland Soil Series	Playa Soil Series/ Miscellaneous Data	Reference
North Rangeland	Baca, Colorado	Aridisol - Argids	Baca, Nunn	No soil designation; classed as intermittent lake.	Woodyard et al. 1973
	Quay, New Mexico	Aridisol - Argids	Church	Unclassified (saline)	Ross and Johnson 1959
	Dallam, Texas	Alfisol - Ustalfs	Conlen, Gruver	Church adjacent to saline playas; Ness on playa bottoms.	Ford and Fox 1975
	Oldham, Texas	Mollisol - Ustolls	Pullman	Randall	Pringle et al. 1980
North Cropland	Stevens, Kansas	Alfisol - Ustolls	Richfield, Dalhart	Lofton	Dickey, Eeds and Hecht 1961
	Texas, Oklahoma	Mollisol - Ustolls	Richfield	Randall	Meinders et al. 1958
	Hansford, Texas	Mollisol - Ustolls	Pullman, Zita, Mansker	Randall	Welker et al. 1960
	Lipscomb, Texas	Mollisol - Ustolls	Pullman, Estacado, Darrouzett	Randall	Williams 1975
Irrigated Cropland	Curry, New Mexico	Mollisol - Ustolls	Pullman, Mansker, Church	Lofton and unclassified	Buchanan and Ross 1958
	Castro, Texas	Mollisol - Ustolls	Pullman, Olton, Lipan, Estacado	Randall	Bruns 1974
South Rangeland	Lea, New Mexico	Mollisol - Ustolls	Kimborough, Stegall	Drake, Cottonwood, Arch, Reeves (commonly saline)	Turner et al. 1974
	Gaines, Texas	Alfisol - Ustalfs	Kimborough, Arvana, Amarillo	Arch and Drake bordering saline playas; Randall in playa bottoms.	Dittemore et al. 1965

Table 3-1. (concluded)

Zone	County, State	Dominant Soil Order	Associated Upland Soil Series	Playa Soil Series/ Miscellaneous Data	Reference
	Glasscock, Texas	Entisol - Orthents	Reagan, Conger	Lipan	Dixon 1977
South Cropland	Cochran, Texas	Alfisol - Ustalfs	Amarillo	Randall	Newman et al. 1964
	Lynn, Texas	Alfisol - Ustalfs	Church, Lubbock, Zita	Randall (often saline)	Mowery and McKee 1959

Table 3-2. Distribution of common playa basin soil types in 31 counties of the Southern Great Plains study area of Curtis and Beierman (1980).

	Randall Clay		Lipan Clay		Ness Clay		Lofton Clay Loam		Other or Unclassified	
	No.	%	No.	%	No.	%	No.	%	No.	%
Colorado	0	0	0	0	0	0	0	0	4	100
Kansas	6	60	0	0	0	0	3	30	1	10
New Mexico	0	0	0	0	0	0	2	9	21	91
Oklahoma	16	100	0	0	0	0	0	0	0	0
Texas-North	11	65	0	0	6	35	0	0	0	0
Texas-Mid	28	80	0	0	0	0	0	0	7	20
Texas-South	0	9	10	91	0	0	1	9	0	0
Study Area	61	53	10	9	6	5	6	5	33	28

Table 3-3. Description of the surface horizon of v[illegible]s playa basin soils (various sources).

Playa Soil (County)	Soil Characteristics						
	Texture	Color	Structure	Consistency	pH	Boundary	Reference
Lofton (Stevens, KS)	Clay Loam	Dark brown	Granular	Hard (dry); friable (moist)	n.a.	Clear	Dickey, Eeds, and Hecht 1961
Stegall (Lea, NM)	Silty Clay Loam	Grayish brown to very dark brown	Very fine, subangular blocky	Slightly hard, friable (moist); sticky and plastic (wet)	Non-alkaline	Abrupt	Turner et al. 1974
Randall (Lipscomb, TX)	Silty Clay	Very dark gray	Moderate, very fine, subangular blocky	Very hard and firm (dry)	Neutral	Clear, wavy	Williams 1975
Randall (Castro, TX)	Clay	Very dark gray	Moderate, fine blocky	Very hard, firm (dry); sticky, and plastic (wet)	Neutral	Diffuse and smooth	Bruns 1974
Randall (Gaines, TX)	Clay	Very dark gray	Moderate, fine to medium, irregular blocky	Hard (dry); firm (moist); very sticky (wet)	Weakly alkaline	Gradual	Dittemore et al. 1965
Randall (Oldham, TX)	Clay	Very dark gray	Moderate, medium, subangular blocky and fine granular	Extremely hard very firm (dry)	Moderately alkaline	Gradual, smooth	Pringle et al. 1980
Randall (Lamb, TX)	Clay	Dark gray	Moderate, fine blocky and irregular blocky	Very hard (dry); very firm (moist); very sticky and plastic (wet)	Weakly alkaline	Diffuse	Newman et al. 1959

Table 3-3. (concluded)

Playa Soil (County)	Soil Characteristics						
	Texture	Color	Structure	Consistency	pH	Boundary	Reference
Randall (Cimarron, OK)	Clay	Dark gray	Coarse, granular to blocky	Very hard (dry)	Neutral to alkaline	Gradual	Murphy et al. 1956
Randall (Texas, OK)	Clay	Dark gray to dark grayish brown	Blocky	Very hard (dry)	Neutral	Gradual	Meinders et al. 1958
Randall (Lynn, TX)	Clay	Dark grayish brown	Massive	Very hard (dry), firm (moist); very sticky (wet)	Weakly acid (6.8)	Abrupt transition	Mowery and McKee 1959
Randall (Cochran, TX)	Clay	Dark brown to very dark gray (browner in sandier soils)	Compact	Sticky (wet)	Weakly alkaline to neutral	Abrupt transition	Newman et al. 1964
Ness (Dallam, TX)	Clay	Gray to very dark gray	Strong, coarse blocky	Extremely hard, very firm (dry)	Mildly alkaline	Smooth	Ford and Fox 1975
Lipan (Glasscock, TX)	Clay	Gray to dark gray	Moderate, fine and medium blocky	Very hard (dry); very firm (moist); very sticky and plastic (wet)	Moderately alkaline	Gradual, smooth	Dixon 1977

Note: Baca County, Colorado, playa soil zones are designated "intermittent lakes," and soils are not characterized.

indicating slumping of surface soils into the deep, wide cracks that appear in dried basin soil (Allen et al. 1972). Surface features of most playas are influenced by the rate of capillary discharge that produces "puffy" ground (expanded pore space and decreased density), as well as the frequency of surface water flooding that removes the surface accumulation due to evaporation, resulting in smooth, extremely flat, hard ground (Neal 1975; Motts 1969). Guthery, Pates and Stormer (1982), noting a further relation between playa soil and water action, reported that the area of a playa basin watershed was positively correlated with the area of the Randall soil zone.

The water retention capacity of playa soils makes them highly attractive to agriculture for water collection, storage, and reuse. Various components of the playa sediments may have economic value, such as clay, sand, gravel, gypsum, borax, lithium, and uranium (Reeves 1978). Reeves reported that in addition to the economic values of playa sediments, these deposits contain the sedimentary history of the region and possess paleo-climatic evidence such as fossil remains of plants and animals.

Resident and migratory wildlife benefit from the enhanced water retention of playa basin soils. High water-holding capability, combined with playa modifications such as diking and excavations, collect and concentrate water, providing a wetland resource in an otherwise dry land (Simpson and Bolen 1981). The U.S. Soil Conservation Service recognizes the wildlife value of playas by assigning a soil suitability rating of "1" (well suited) for the aquatic and semi-aquatic habitats that result from water retention by playa clay.

3.2 HYDROLOGY OF PLAYA BASINS

Playa basin hydrology is influenced by agricultural practices, including basin modification for water collection and retention and grazing in the watershed. Water reaching the playa is derived primarily from precipitation and runoff within the basin watershed. Water retention times range from temporary to long-term, depending on regional soil zone characteristics, local playa soil types, evapotranspiration processes, and amounts of precipitation and runoff. Interactions between groundwater and playa lakes or wetlands are generally restricted to spring flow into playas.

Natural Versus Modified Surface Runoff. The playa basin system of the Southern High Plains (Llano Estacado) functions as the main regional drainage network; no significant stream drainage system exists (Figure 3-3). These basins collect water primarily in two peak periods–May and September–as a result of regional convection storms. Playa basin water collection typifies the seasonal and long-term extremes of the region; periods of flood and drought are likely and occur frequently over time.

The average playa basin surface density varies considerably from county to county within the study region (Figure 3-4). Aronovici, Schneider and Jones (1970) reported an estimated average runoff into Southern Great Plains playas ranging from 2 to 3 x 10^6 ac-ft/yr (2.5-3.7 x 10^9 m^3/yr), amounts which are equivalent to one-fourth to one-third of the water pumped from the Ogallala Aquifer for irrigation in this region. However, a subsequent estimate ranged up to 8 x 10^6 ac-ft (9.9 x 10^9 m^3) during a wet year (Palacios 1981). The accumulations of runoff vary with the amounts of precipitation, watershed size and condition, soil characteristics, degree of slope, rates of infiltration and evaporation, land use, and conservation practices (Dvoracek and Black 1973). Direct rainfall into the playa basin is a significant factor accounting for large volumes of water accumulation, according to Dvoracek and Black.

Runoff into playa basins is influenced by the surrounding soil texture; greater volumes of runoff are recorded on

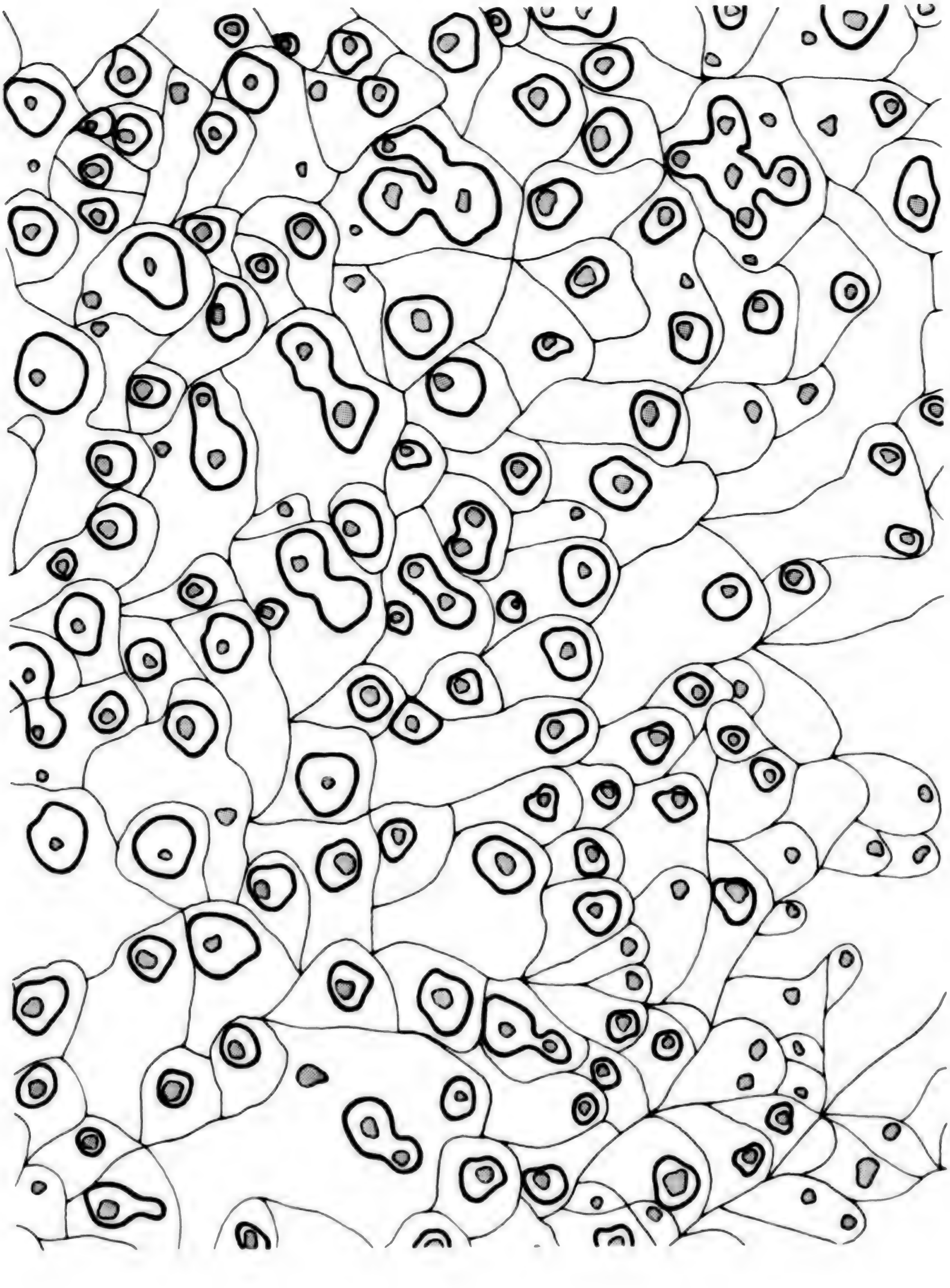


Figure 3-3. Pattern of playa basins with internal Randall soil zones and surrounding watersheds for an area in Lubbock County, Texas (Bowden 1967).

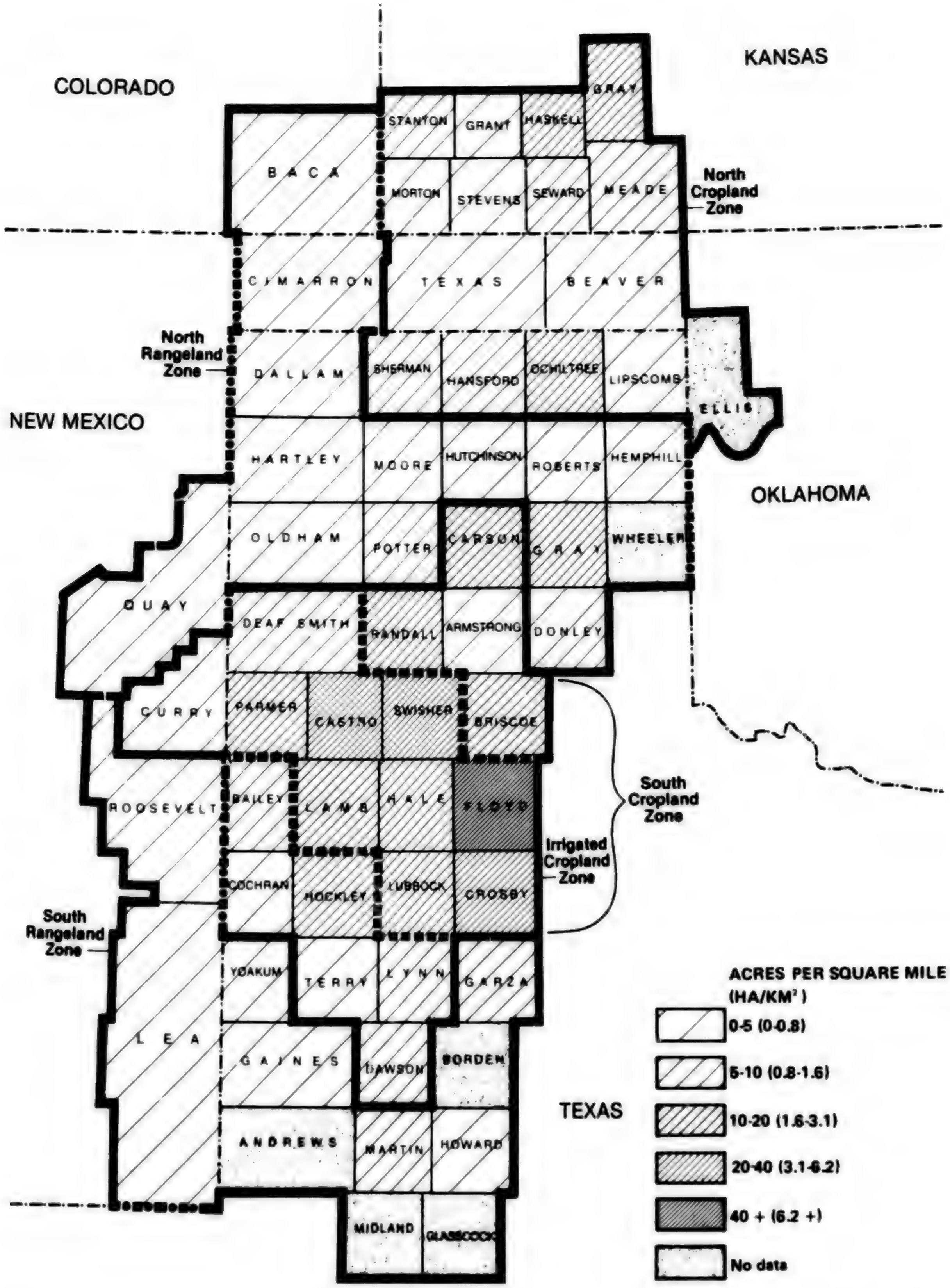


Figure 3-4. Average dry playa basin surface density, by counties within the study region (adapted from Schwiesow 1965, Dvoracek and Black 1973, and Guthery et al. 1981).

MICROFI[illegible] BEST AVAIL[illegible]PY

fine-textured soil, with successively lesser amounts on medium- and coarse-textured soils. Watershed size and condition affect the volume of water delivered to the playa basin. For instance, one-half inch (1.3 cm) of rainfall in a playa watershed could produce 4 to 5 ac-ft (4,900-6,200 m^3) of runoff during the spring, but no runoff from a similar storm in late summer, the main difference being the extent of soil disking and vegetative cover (Lubbock City-County Health Unit 1962). Playa watershed slopes also influence runoff, producing increased runoff and decreased infiltration as the slope increases. Moore (1980) states one important influence of land use on playa water supply; basins receiving irrigation tailwater sustained a larger water surface area or volume for a longer period than those dependent solely on rainfall. Playas modified to receive irrigation tailwater collect from 1 to 2 x 10^6 ac-ft/yr (1.2-2.5 x 10^9 m^3/yr) or approximately one-fifth of the irrigation water pumped in the Texas High Plains (High Plains Underground Water Conservation District No. 1 1977). Most of the water collected in playas is reused for irrigation or is lost by evaporation (Jenkins and Hofstra 1970).

Playa Water-Holding Capacity. Taken in perspective, playa basins are dry most of the time; the term "playa lake" is used when the basin surface is covered with water (Motts 1969). Prior to Southern Great Plains agriculture, water retention in the basin was balanced between precipitation and evaporation. Factors associated with present agricultural practices influence playa water permanence; playa lakes may be either ephemeral or relatively permanent in water retention as a result of modification. Wet-and dry-season average playa water surface density, derived from recent LANDSAT imagery (1974 and 1978), varies considerably among counties within the Southern Great Plains study region (Figures 3-5 and 3-6).

Motts (1969) presented the concept of flooding ratio, describing the length of time that water remains in a playa as a means of differentiating between playas and playa lakes. The percentage of days per year that a playa contains open water defines a yearly flooding ratio. Motts noted, however, that a 10-year flooding ratio may be of more value as the longer time frame offsets potentially erratic annual precipitation. A yearly flooding ratio of less than 0.25 (25%) for several years would classify the basin as a playa; whereas a basin with a flooding ratio of greater than 0.75 (75%) would qualify as a lake. Based on a rather small (0.4%) nonrandom sample, Curtis and Beierman (1980) estimated the persistence of playa water during 1979 within the five-state study region (Table 3-4). As compared to 33% of playas estimated by Curtis and Beierman to contain water more than nine months of the year (spring-summer-fall), Guthery et al. (1981) found that 10% of *unmodified* playas contained water in a drouthy summer (1980), based on a 9% random sample. There may be little discrepancy here since over two-thirds of the playas classed as perennial by Curtis and Beierman had been *modified.*

Playa water-holding potential varies with the degree of lake-bottom saturation and the prevailing evapotranspiration rate. Because of the lack of outlets, large surface area, and shallow depths of most unmodified playas, the bulk (90%) of accumulated water is lost through evapotranspiration (Aronovici, Schneider and Jones 1970; Lubbock City-County Health Unit 1963; Reed 1930). Grubb and Parks (1968) reported playa evaporation losses exceeding 0.9 ac-ft of water per surface acre (450 m^3/ha) during a month; according to unpublished Bureau of Reclamation data, losses may exceed 2.0 acre-feet per surface acre (1,000 m^3/ha) at times (Guthery et al. 1981). The monthly distributions of rainfall, evaporation losses, and average playa water volume in the vicinity of Lubbock, Texas, have been documented (Figure 3-7).

Interactions with Groundwater and the Ogallala Aquifer. Playa basin water infiltration rates may be rapid initially because of

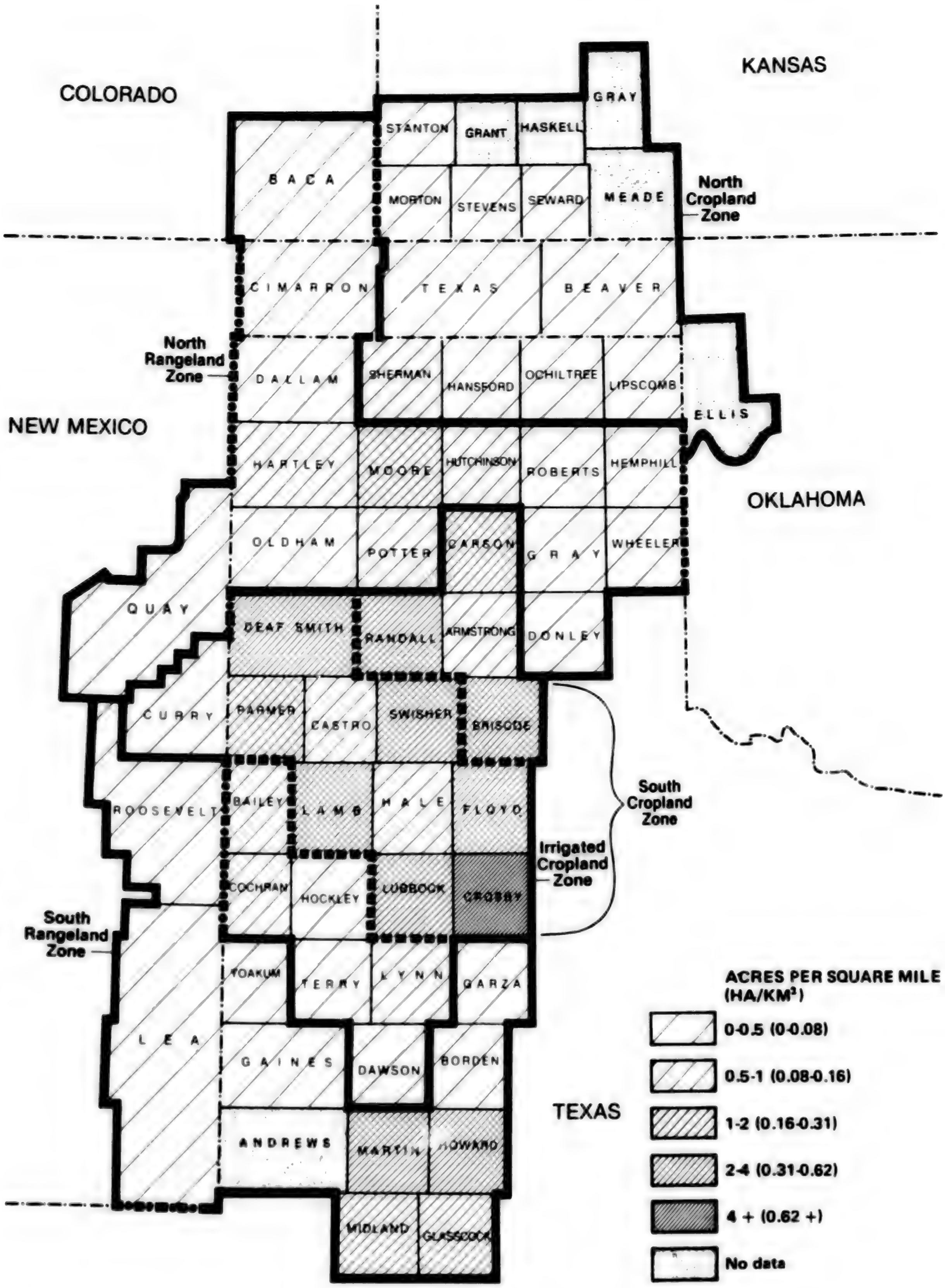


Figure 3-5. Average wet season playa water surface density, by counties within the study region (U.S. Bureau of Reclamation Playa Inventory 1982).

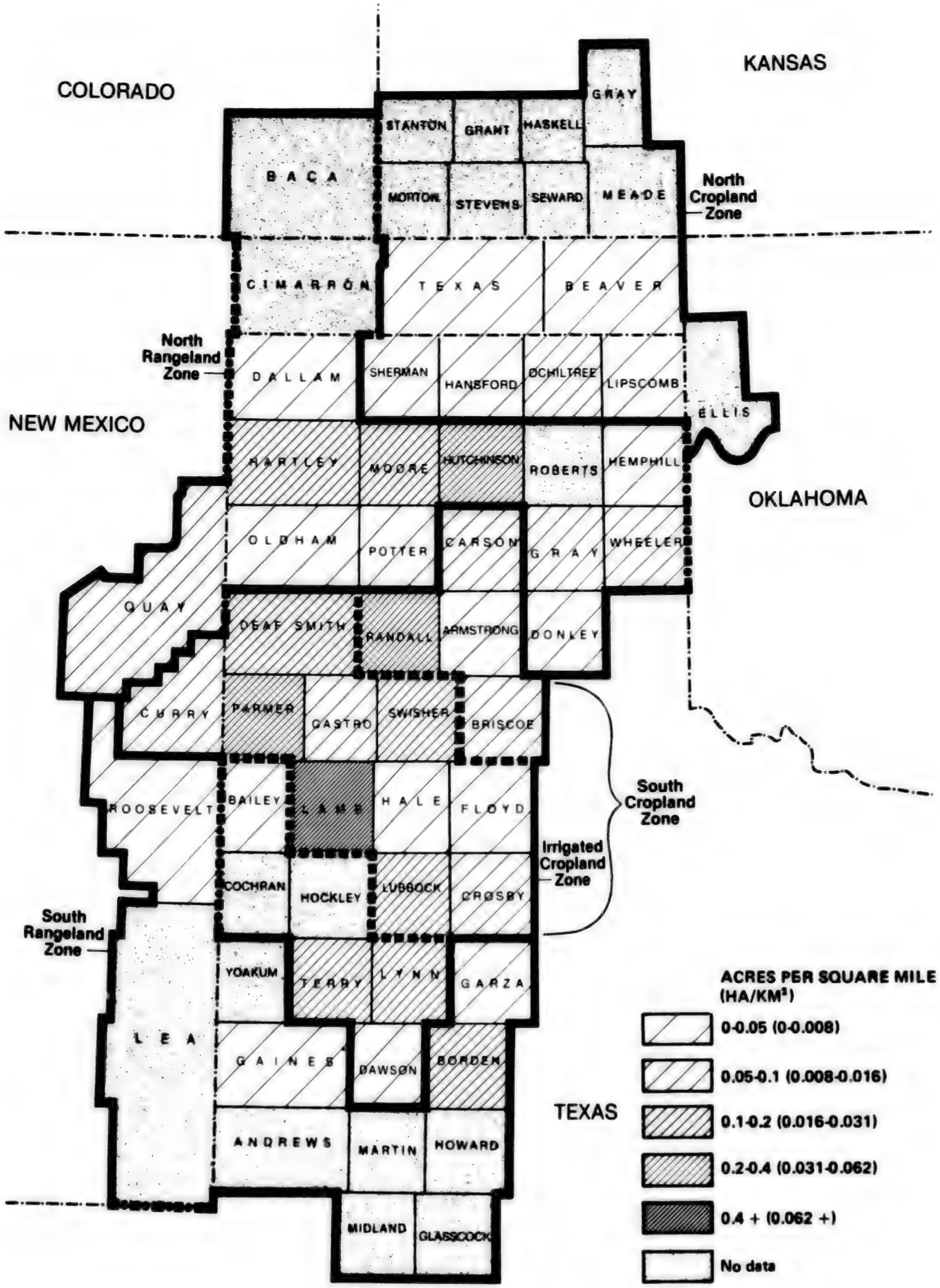


Figure 3-6. Average dry season playa water surface density, by counties within the study region (U.S. Bureau of Reclamation Playa Inventory 1982).

Table 3-4. Estimated rates of playa water persistence in 31 counties of the Southern Great Plains study area of Curtis and Beierman (1980).

	Perennial[1]		Intermittent[2]		Ephemeral[3]		Perennial With Pit, Pond or Ditch in Basin	
	No.	%	No.	%	No.	%	No.	% of Perennial Playas
Colorado	3	75	0	0	1	25	3	100
Kansas	4	40	2	20	4	40	3	75
New Mexico	5	22	10	43	8	35	4	80
Oklahoma	2	13	1	6	13	81	1	50
Texas-North	9	53	3	18	5	29	5	56
Texas-Mid	13	37	12	34	10	29	8	62
Texas-South	3	27	1	9	7	64	3	100
Study Area Total	38	33	30	26	48	41	27	71

[1] Normally containing water more than nine months of the year.

[2] Normally containing water from three to nine months of the year.

[3] Normally containing water less than three months of the year.

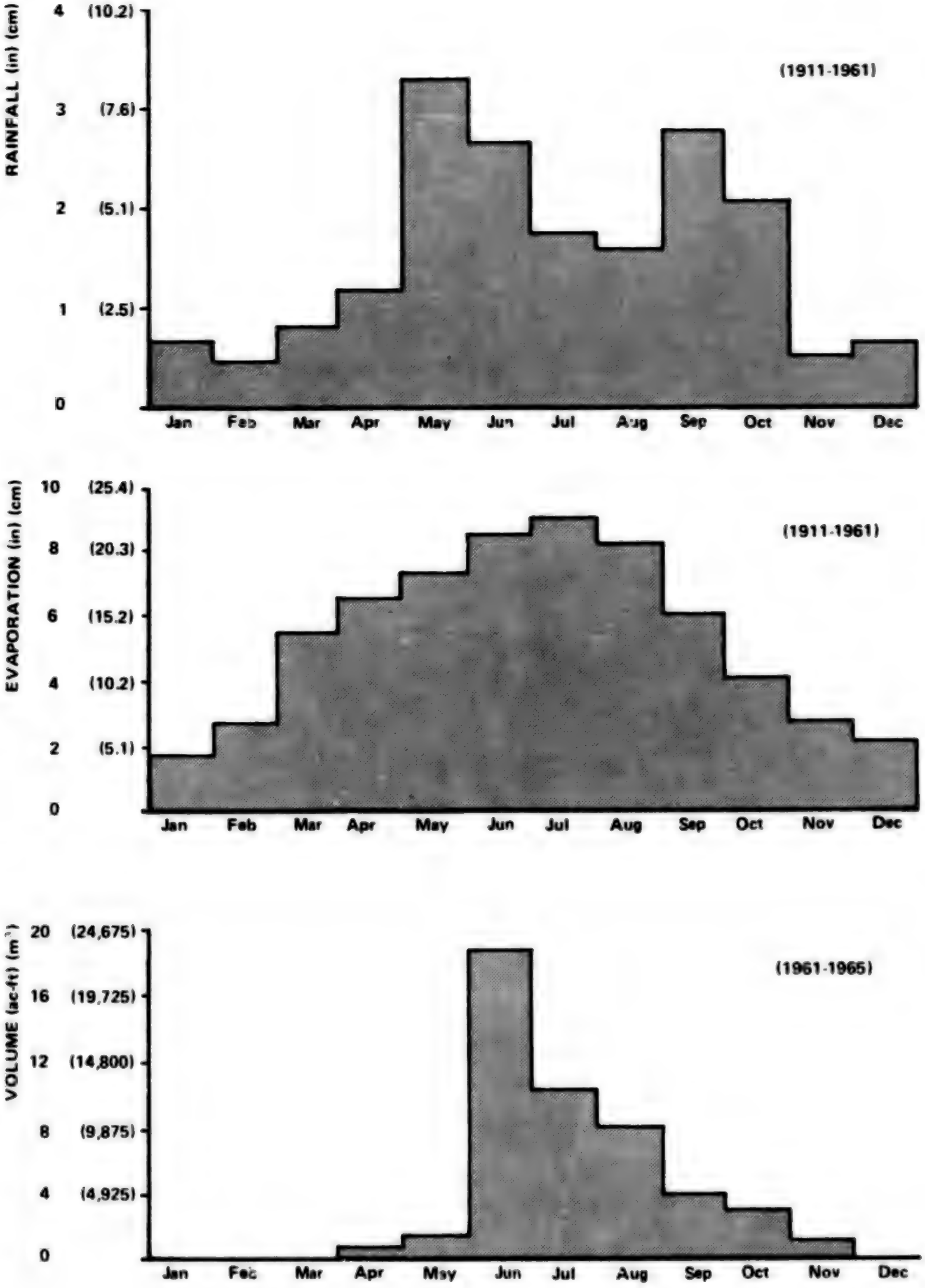


Figure 3-7. Monthly distribution of rainfall, free-surface evaporation losses, and average water volume of unmodified playas in the vicinity of Lubbock, Texas (Ward and Huddleston 1972).

dessication cracks, but decrease rapidly as the clay particles expand with water (Harris et al. 1972). Allen et al. (1972) concluded that little water percolation or Ogallala Aquifer recharge occurs through playa soils. Dvoracek (1981), however, reported that about 10% of playa water infiltrates to naturally recharge the aquifer. Templer (1978) observed that high percolation rates (10-15% of accumulated water) occur only in the southern sandy loam areas of the Southern High Plains (Llano Estacado) from the small lake basins of that region.

Playas are geologically uncommon in that they concentrate total interior drainage of both surface and groundwater. Because playas often occupy the lowest elevations of the region, they may interact with groundwater, which can occur in three ways: by plant uptake and evapotranspiration; by capillary discharge through the playa surface, originating from aquifers by artesian movement; and discharge from springs that occur near junctions of fine-grained upland soils (Motts 1969). Capillary discharge depends on groundwater depth and circulation; water table depths greater than 5 m produce little discharge, resulting in dense playa crusts having little accumulation of evaporative salt deposits (Neal 1975).

Reeves (1970) observed that some of the playa basins on the Texas High Plains had flowing springs; most were intermittent with substantial variation in annual flow. Three major types of playa springs have been identified: runoff, Cretaceous, and Ogallala springs (Table 3-5).

3.3 PLAYA WATER CHEMISTRY AND QUALITY

Playa water quality ranges from superior in freshwater playa lakes to inferior in saline playas. Pollution of playas may derive from agricultural, municipal, and industrial sources, with the latter posing more persistent contamination in a small number of playas. Water in freshwater playas is supplied mainly from precipitation and therefore is usually of excellent chemical quality. Playa springs, on the other hand, interact with mineral deposits, which considerably reduce basin water quality.

Saline playas, referred to as "salt lakes" on the Llano Estacado (Southern High Plains), contrast sharply with freshwater playas (Allen et al. 1972). The salt playas are most common in Andrews, Gaines, Hockley, Lamb, Lynn, and Terry Counties of Texas; their development apparently has depended on the presence of exposed Cretaceous sediments (Rettman 1981; Allen et al. 1972). Saline playa basins may be several square miles (7 or 8 km^2) in extent, with water availability more a function of water table fluctuations than amounts of surface runoff. These "salt lake" basins reveal a white salt crust during periods of lowered groundwater (Allen et al. 1972). High sodium chloride, calcium sulfate, ferric sulfate, and other dissolved mineral concentrations of the saline playas create a different ecosystem compared to freshwater playas. These high salt levels limit the production of most aquatic vegetation and invertebrate species (Pence 1981).

Unpolluted Playa Water Quality. The water quality of uncontaminated freshwater playa lakes tends to be similar throughout the Southern High Plains (Llano Estacado), regardless of soil textural zone (Lotspeich, Hauser and Lehman 1969). Compared with Ogallala groundwater, playa lakes generally have lower dissolved solids, but much higher levels of suspended solids and bacteria (Wells, Huddleston and Rekers 1970). Frequent winds in the region and a lack of windbreaks perpetuate high suspended solids (turbidity) levels in playa water; this condition increases as the lakes dry. Also, Sublette and Sublette (1967) attributed higher turbidity levels of certain playas to poorly vegetated watersheds.

Other playa water chemistry values are consistent with good quality irrigation water:

Table 3-5. Major types of playa-associated springs in the Texas High Plains (after Reeves 1970).

Runoff Springs	o	Flow mainly after wet periods
	o	Usually located along base of Eolian dunes on east and northeast sides of present playas
	o	Tend to reappear in same location annually, the area frequently becoming "quick" when saturated.
Cretaceous Springs	o	Flow year-long at steady rate
	o	Usually located on southwest, west, or northwest sides of present playas, near or directly above Cretaceous rock outcrops.
Ogallala Springs	o	Flow mainly during the period of September to April, apparently in response to cessation of irrigation
	o	Usually located away from present playa edge, occurring along drainage channels or escarpments on the southwest, west, and northwest basin sides.

pH ranges from 7.0 to 9.0; nitrates are generally below 2.0 mg/ℓ; and chlorides are below 10 mg/ℓ (Lehman 1972; Lotspeich, Hauser and Lehman 1969). Water chemistry values have been determined from four playa lakes near Lubbock, Texas (Table 3-6).

Playa Water Contamination. Playa basins concentrate runoff water from the surrounding watershed, ultimately accumulating various soluble compounds that may have been applied to the adjacent land or placed directly within the basin. Playas may sustain increased loads of somewhat persistent contaminants because these basins constitute the major drainage system of the Llano Estacado (Southern High Plains), and the relatively impermeable playa clays hold the pollutants within upper surface layers (Wells, Huddleston and Rekers 1970; Lubbock City-County Health Unit 1963).

Typical sources of playa contamination include agricultural chemicals (fertilizers, herbicides, and insecticides), runoff from cattle feedlots, municipal sewage and stormwater effluents, petroleum development wastes such as brine, and other industrial or military discharges. Some degree of contamination from agricultural chemicals can be expected, depending on the application rates, chemical persistence, water drainage sources, and the drainage surface area. Insecticides are sometimes directly applied to playas for mosquito control.

Playa water quality studies have detected fertilizers (nitrate and phosphorous), herbicides and insecticides in selected playas at concentrations low enough to designate these waters safe for consumption by humans and livestock (Wells, Rekers and Huddleston 1970; Lotspeich, Hauser and Lehman 1969). Sediment samples from playas selected for wide land use representation were found to contain aldrin, dieldrin and DDT in concentrations generally well below 1 ppm (Figure 3-8) (Wells, Rekers and Huddleston 1970). No measurable concentrations of herbicides were reported. Due to the shrink-swell process and cracking of playa soils, contaminants can move downward and surface exposure is reduced.

Table 3-6. Results of complete analysis of water from four representative playa lakes near Lubbock, Texas, in September and October 1961 (Lubbock City-County Health Unit 1962).

Chemical Parameter	Concentrations (ppm)			
	Lake I	Lake II	Lake III	Lake IV
Calcium	40	34	54	32
Magnesium	9	4	12	12
Iron	0.98	0.55	6.3	2
Manganese	0.05	0.05	0.05	0.05
Sodium	10	3	27	22
Carbonate	0	0	0	0
Bicarbonate	155	124	196	185
Sulphate	26	8	59	12
Chloride	14	2	26	14
Fluoride	1.1	1.2	1.2	1.2
Nitrate	0.4	0.4	0.4	0.4
Dissolved Residue (T.S.)	210	138	355	245
Phenophthalein Alkalinity as $CaCO_3$	0	0	0	0
Total Hardness as $CaCO_3$	155	102	161	152
Specific Conductance (μmhos/cm)	350	230	592	408
pH (units)	7.2	7.9	7.9	7.9

Contamination of playa basins resulting from collection of feedlot runoff has produced high ammonia, nitrate and bacterial levels in local playas, although little groundwater pollution has resulted because of impervious clay in the playa bottom (Wells, Rekers and Huddleston 1970). Petroleum production wastes (oil, brine, and related substances) have been reported at several playas, most prominently from Lake Whalen, Texas, where hydrocarbon levels ranging from 176 to 481 ppm have been detected (Vogler 1979). Curtis and Beierman (1980) noted that municipalities, industries and the military have used some playa basins as holding or disposal ponds for waste discharge. Although the pollution is presently confined to only a few basins in the region, the future potential for playa contamination may be significant because of direct exposure and bioavailability.

The quality of spring waters flowing into Texas High Plains playa basins is generally poor (Reeves 1970). Of the playa springs tested for water quality, most exceeded 500 ppm of total dissolved solids, 1.7 ppm of fluoride, 50 ppm of magnesium, and 250 ppm for both chloride and sulfate. Passage through saline sediments causes runoff spring water to deteriorate. Cretaceous springs arc reported to have uniformly poor water quality, while Ogallala springs tend towards marginal quality because of the surrounding saline sediments (Reeves 1970).

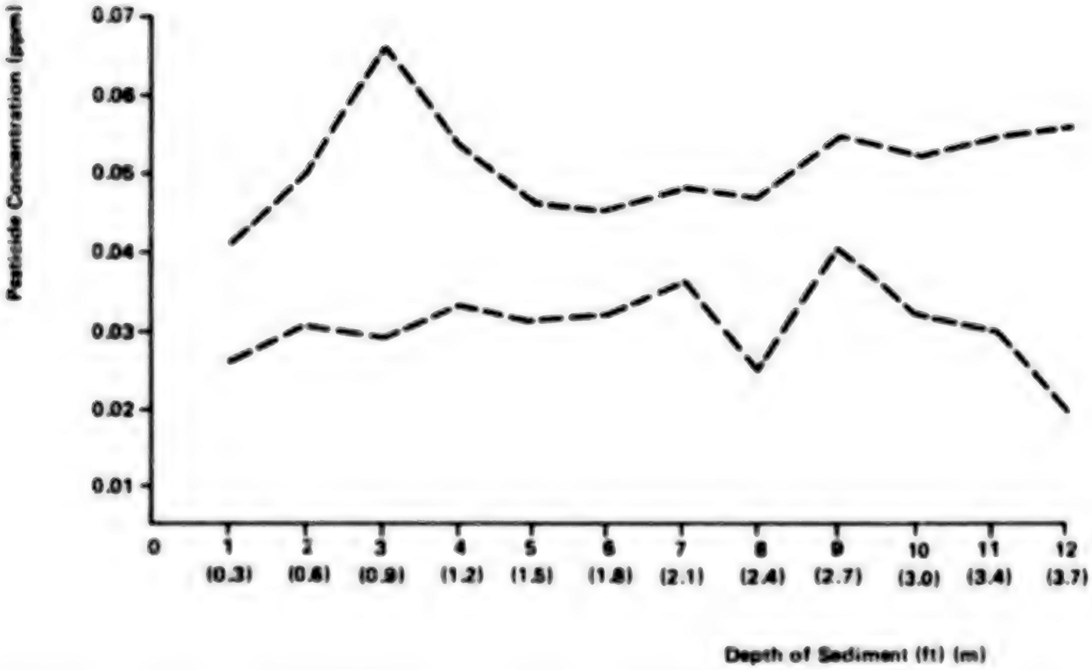


Figure 3-8. Dieldrin concentrations in sediment layers of two rural playa lakes in Lubbock County, Texas (Wells, Rekers and Huddleston 1970).

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4.0 ECOLOGY OF PLAYA BASINS

Playa habitat classification following the National Wetland Classification System treats all playas as palustrine or lacustrine wetlands. Habitat values hinge on the collection of irrigation tailwater, as well as watershed size, water surface area and depth, water persistence, height and density and interspersion of vegetation, and the extent of basin cultivation, grazing, and excavation to concentrate water. Playas may ensure valuable winter cover for upland birds, and those containing open water provide valuable loafing, roosting, watering, and foraging sites for migratory waterfowl. Playa bird populations of importance include upland game birds, raptors, and passerines, in addition to overwintering waterfowl. Other wildlife populations of importance include many furbearers and a few reptiles and amphibians; most fishes are introduced. Invertebrate production is important in the playa food chain. Wildlife diseases associated with playa basins are encephalitis, avian cholera, botulism, and duck schistosomiasis.

4.1 HABITAT CLASSIFICATION AND VALUES

A variety of habitat classification systems has been devised to encompass the diversity of habitats afforded by playas and other wetlands. When the playa basins collect natural runoff and irrigation tailwater, a great biomass of vegetation may be produced, providing a variety of cover and food for a diverse community of wildlife. In an agriculturally intensive and, for the most part, dry region, many playas appear as "islands" of wetland habitat and serve to concentrate wildlife.

Systems of Classification. Several systems of ecological classification have been applied or devised in attempts to differentiate and characterize playa basins. According to Cowardin et al. (1979), playas are classified as palustrine wetlands which have less than 20 surface acres (8.1 ha) of water, less than 2 m of depth at low water, and/or greater than 30% coverage of emergent vegetation. Common class and subclass categories are vegetated or mud flats and persistent or nonpersistent emergent wetlands. Stormer, Bolen and Simpson (1981) believed that the Cowardin system could be useful in playa classification, although it would not provide adequate definition for localized research and management.

Simpson and Bolen (1981) suggested a localized playa classification composed of six categories based upon water retention, type of vegetation, and height of vegetation (Table 4-1). These authors reported that the physiognomy of cover (height, density, and other physical characteristics of the vegetation) is more valuable for classification purposes than the vegetative species, especially regarding wildlife values. A playa with low vegetative diversity and interspersion, encroaching cropland, and an ephemeral water regime would have relatively low value as wildlife habitat (Figure 4-1). Moore (1980) used a simplified playa classification based on broad classes of vegetation: emergent cover; partial emergent cover; agricultural cover; and rangeland (Table 4-2).

Guthery and Bryant (1982) applied a playa classification system for a 52-county area of the Southern Great Plains that included plant communities, water persistence, land use, and playa modifications in the characterization of playa wildlife habitat (Table 4-3). Playa habitats were classified as low value (farmed), low value (grazed), moderate value, and high value. Guthery and Bryant regarded the playa habitat value as species-specific; they noted, however, that playas classified as moderate to high in value are relatively more important to wildlife as they contribute more habitat interspersion and diversity.

Guthery (1980) and Guthery, Pates and Stormer (1982) developed a playa

Table 4-1. Six categories of playas based on water retention, type of vegetation, and height of vegetation (after Simpson and Bolen 1981).

(1) *Agricultural-Ephemeral*: Surrounding land totally or predominantly in crop production with varying degrees of cultivation encroaching on basin borders; water availability is variable.

(2) *Agricultural-Permanent*: Similar to "Agricultural-Ephemeral," but with some water present throughout the year.

(3) *Rangeland-Ephemeral-Tall*: Mostly rangeland with basins usually fenced; ephemeral water; tall vegetation.

(4) *Rangeland-Ephemeral-Short*: Similar to "Rangeland-Ephemeral-Tall," but vegetation is less than one meter in height; generally grazed heavily.

(5) *Rangeland-Permanent-Tall*: Similar to "Rangeland-Ephemeral-Tall," but with year-round water retention.

(6) *Rangeland-Permanent-Short*: Similar to "Rangeland-Permanent-Tall," but without well developed marginal communities of tall plants, and lacking the taller grasses.

Table 4-2. Playa classification based on four vegetative cover types (after Moore 1980).

Category 1: Playa lakes with more than 25% of area covered by emergent vegetation (i.e., cattails, bulrush).

Category 2: Playa lakes with less than 25% of area occupied by emergent vegetation.

Category 3: Agricultural crops planted into or through the playa basin regardless of the percentage covered by emergent vegetation.

Category 4: Rangeland vegetation is dominant with little or no emergents; generally grazed.

Table 4-3. Playa classification based on plant communities, water persistence, land use, and playa modifications (after Guthery and Bryant, in press).

(1) *Low Habitat Value-Farmed*: Area occupied by persistent, natural plant communities is less than one hectare, with the remainder of the playa disked or cropped, regardless of size.

(2) *Low Habitat Value-Grazed*: Playa area generally lacks plant communities because of heavy grazing, regardless of size.

(3) *Moderate Habitat Value*: Playas that provide one to eight hectares of persistent natural plant communities that are ungrazed or lightly grazed, regardless of modification or cultivation in other portions of the basin.

(4) *High Habitat Value*: Playa area and associated wildlands total eight hectares or more and support growth of permanent vegetation or permanent open water, regardless of cultivation or modification in other portions of the basin.

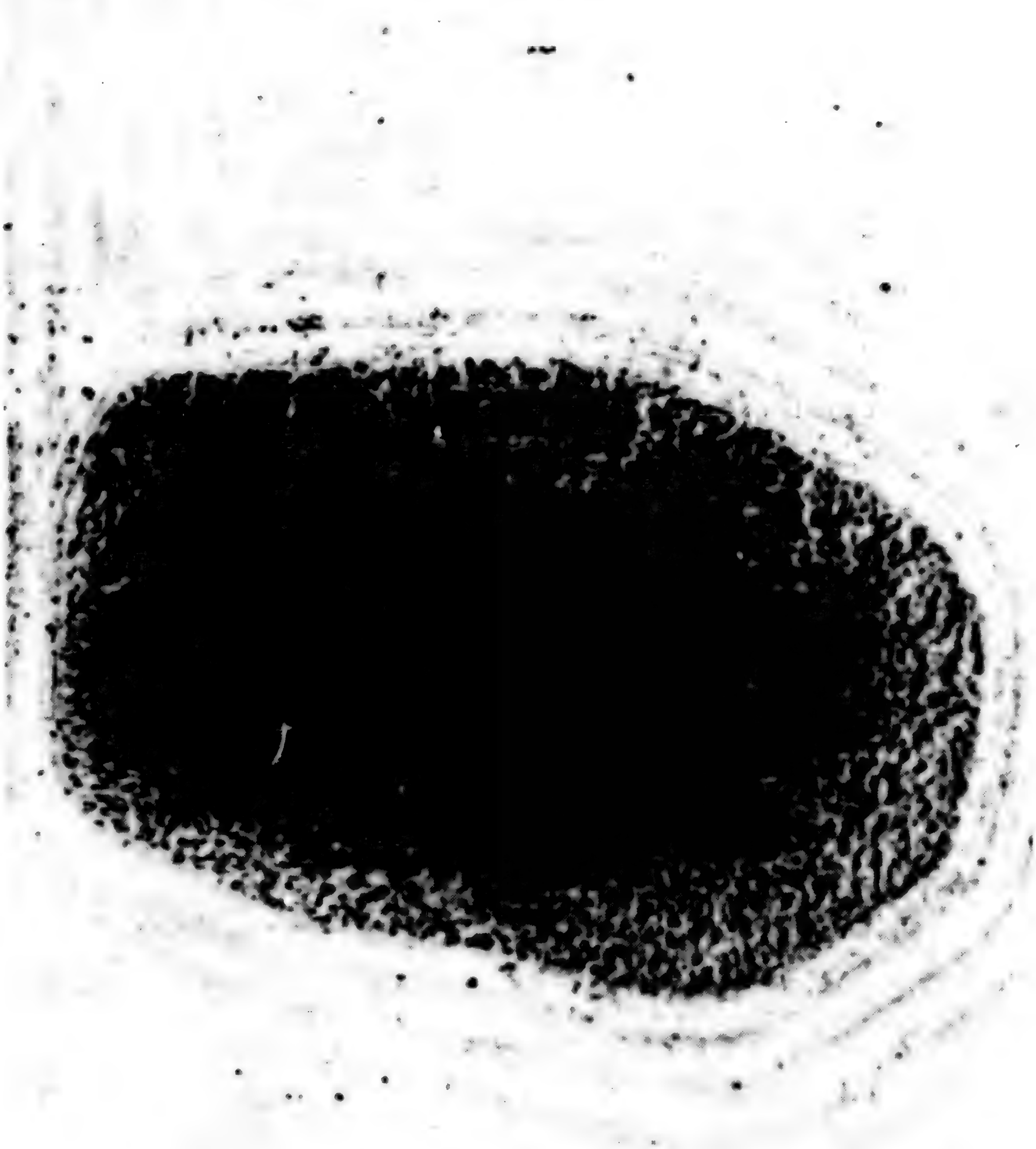

Figure 4-1. Agricultural playa with a mix of mesic disturbed forbs and wheat crops at the perimeter yields poor wildlife habitat due to low vegetative diversity and interspersion. Entire basin has been plowed; contour furrows surrounding the basin help to conserve surface runoff (Texas Tech University, Department of Range and Wildlife Management 1981).

classification system composed of 64 variables reflecting land use and playa modification, physical features, soils, and vegetation (Table 4-4). Factor analysis of floristic data collected from playas in Bailey, Castro and Lamb Counties of the southwest Texas Panhandle was used to examine vegetative associations with typical environmental influences; 14 physiognomic types were identified (Table 4-5). Twenty playa types were isolated through cluster analysis of these data (Table 4-6). Factors considered most responsible for clustering of vegetative and physiognomic variables include moisture regime, soil disturbance, and stability of flora. Guthery (1980) observed that different clusters could result in different years because of rapid playa changes resulting from variations in rainfall and basin management.

The distribution of open water surface area within playa basins by county and size class during wet and dry seasons in the 1970's has been documented (Figures 4-2 and 4-3). The distribution demonstrates the variability of playa lakes and wetlands, depending on overall precipitation and runoff. Also, it underscores the widespread availability of open water for wildlife during a wet season, and very curtailed but critical availability in a dry season.

Playa Values for Wildlife. Wetlands tend to promote greater productivity than most other naturally occurring ecosystems. Nutrient exchange is enhanced in playa wetlands by periodic drying; this process accelerates plant growth, increasing food and cover for wildlife (Simpson and Bolen 1981). Most wetland habitats on the Southern Great Plains are furnished by playa basins; in wet years they provide 230,000 to 250,000 surface acres (93,000-101,000 ha) of aquatic habitat (Curtis and Beierman 1980; Sanderson 1976). Pence (1981) noted that a majority of wildlife populations of the region are associated with playas. The basins are a natural attraction for terrestrial and aquatic wildlife, and are responsible for regional waterfowl abundance, providing many features essential for their existence (Bolen and Guthery 1982; Green 1972).

The primary factor determining wildlife species composition and abundance, habitat value and use is the greater floral biomass and tall, persistent vegetative cover afforded by the wetter soils of playa basins (Curtis and Beierman 1980; Bolen, Simpson and Stormer 1979). Agricultural practices of the playa region such as monoculture, weed control, and clean tillage ensure that cover, except for crops, is nearly nonexistent; what cover does exist is confined largely to the playa basins except in rangeland zones. Conflicts may occur in agricultural areas where playa basins providing wildlife habitat when flooded in wet years are cultivated in drier years with a loss of habitat (Figure 4-4). Other interactions between farming activities and a playa basin have substantially increased the wildlife habitat value (Figure 4-5). Playa vegetation may offer habitat having high ecotone (edge effect) and the only suitable vegetative cover, especially during fall and winter, allowing resident wildlife to persist and migratory wildlife to overwinter and breed in the spring (Guthery 1981a; Simpson and Bolen 1981). Playa basins have a unique vegetation, differing substantially in species and frequency of occurrence from plant communities of the surrounding prairie. The vegetative cover is quite variable, depending on the season of basin flooding and the period of inundation; plants range from annual and perennial forbs and grasses to wetland and woody vegetation associated with riparian woodlands (Rowell 1981; Curtis and Beierman 1980). (Appendix A contains a checklist of plant species associated with playa basins.)

Because of the wide variation in playa types and vegetation, habitat value varies for different animal species. Some playas offer a variety of habitat for both terrestrial and aquatic wildlife (Figure 4-6). Guthery and Bryant (1982) concluded that nearly 13% of about 25,000 Southern Great Plains playas had moderate- to high-value wildlife habitat in August 1980; three-quarters were found in

Table 4-4. Components of a playa classification system based upon land use, floristic, soil and physical variables (after Guthery 1980).

Land Use Variables

(1) Type of modification (i.e. physical interference with natural basin hydrology)

- o Central levee
- o Central pit
- o Central pit and peripheral levee with ditch
- o Central levee with adjacent ditches and peripheral ditch
- o Central levee with one or more ditches leading into it
- o Peripheral levee
- o Peripheral levee with peripheral pit
- o Peripheral pit with one or more ditches leading into it
- o Trench excavation across the Randall soil zone
- o Unmodified

(2) Cubic meters of soil excavated for modifications

(3) Presence or absence of irrigation tailwater recovery within the Randall soil zone

(4) Number of irrigation pumps present

(5) Percentage of basin outside the Randall soil zone in contour furrowing

(6) Percentage of Randall soil either disked, plowed, or planted in crops

(7) Presence or absence of grazing within the Randall soil zone

Floristic Variables

Bur sedge - *Echinodorus* sp.
Water clover - *Marsilea* sp.
Arrowhead - *Sagittaria* sp.
Cattail - *Typha* spp.
Spikerush - *Eleocharis* spp.
Pondweed - *Potamogeton* sp.
Bulrush - *Scirpus* spp.
Buffalograss - *Buchloe dactyloides*
Wheatgrass - *Agropyron smithii*
Vine mesquite - *Panicum obtusum*
Johnsongrass - *Sorghum halepense*
Amaranth - *Amaranthus* spp.
Gray ragweed - *Ambrosia grayii*
Marestail - *Conyza canadensis*
Helenium - *Helenium* sp.
Annual sunflower - *Helianthus annus*
Curltop smartweed - *Polygonum lapathifolium*
Dock - *Rumex* spp.
Verbena - *Verbena* sp.
Elm - *Ulmus* sp.
Saltcedar - *Tamarix gallica*
Barnyardgrass - *Echinochloa crus-galli*
Canarygrass - *Phalaris carolinensis*
Kochia - *Kochia* spp.
Devilweed - *Aster spinosus*
Lambsquarters - *Chenopodium* sp.
Wild lettuce - *Lactuca* sp.
Blueweed - *Helianthus ciliaris*
Smartweed - *Polygonum amphibium*
Tumbleweed - *Salsola kali*
Cocklebur - *Xanthium* sp.
Willow - *Salix nigra*

Soil and Physical Variables

(1) Area of watershed

(2) Type of Randall soil

(3) Area occupied by Randall soils within the watershed

(4) Area occupied by fine sandy loams within the watershed

(5) Area occupied by loams within the watershed

(6) Area occupied by clay loams within the watershed

(7) Area occupied by all other soil series within the watershed

Table 4-5. Names, attributes, and prevalence of physiognomic types at playas (n=101) of Bailey, Castro and Lamb Counties, Texas (after Guthery, Pates, and Stormer 1982).

Physiognomic Type	Height of Vegetation (m)	Dominant[1] Taxa (feature)	Secondary[1] Taxa (feature)	Playas With Each Type (%)
Open water		Pondweed (*Potamogeton* spp.)	Arrowhead (*Sagittaria longiloba*)	28
Broad-leaved emergent	0.5-1.2	Smartweeds (*Polygonum bicorne, P. lapathifolium*)	Barnyardgrass Spikerush (*Eleocharis* spp.)	36
Narrow-leaved emergent	1.0-1.5	Cattail (*Typha domingensis*) Bulrush (*Scirpus* spp.)		13
Mesic forb	0.2-1.0	Devilweed (*Aster spinosus*) Gray ragweed (*Ambrosia grayi*)	Smartweeds Barnyardgrass Spikerush	26
Wet meadow	0.2-1.0	Barnyardgrass (*Echinochloa crusgalli*) Red sprangletop (*Leptochloa filiformis*)	Smartweeds Spikerush Devilweed	41
Johnsongrass	0.5-1.5	Johnsongrass (*Sorghum halepense*)		17
Disturbed forb	0.5-1.5	Kochia (*Kochia scoparia*) Blueweed sunflower (*Helianthus ciliaris*)	Horseweed (*Conyza canadensis*) Wild lettuce (*Lactuca* spp.)	9
Cultivation	Variable	Crop		20
Mudflat	<0.5	Absence of vegetation	Barnyardgrass Water-hyssop (*Bacopa rotundifolia*)	16
Spoil bank		Kochia Camphor-weed (*Heterotheca* spp.)	Tumbleweed (*Salsola kali*)	17
Midgrass	0.5	Western wheatgrass (*Agropyron smithii*) Vine-mesquite (*Panicum obtusum*)		1
Shortgrass	<0.2	Buffalograss (*Buchloe dactyloides*)	Gray ragweed	13
Road-pit[2]	Variable	Absence of vegetation		12
Tree-shrub	Variable	Willow (*Salix nigra*) Saltcedar (*Tamarix gallica*) Siberian elm (*Ulmus pumila*)		21

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[1] Dominant taxa were those that were most prevalent in terms of coverage; secondary taxa were those that commonly occurred in a type, but had lower coverage than the dominant taxa.

[2] The road-pit physiognomic type refers to calcareous spoil (caliche) deposited for road fill or excavated from borrow pits in the basin.

Table 4-6. Playa types (n=101) based on watershed, soil, and vegetative variables, and playa modifications in Bailey, Castro and Lamb Counties, Texas (after Guthery 1980).

Playa Type	Number in Sample	$\bar{x}$ Watershed Size (ha)	$\bar{x}$ Randall Soil Zone Size (ha)	$\bar{x}$ Size of Randall Zone Modification (m³)	Extent of Modification or Particular Plant Communities Within Randall Soil Zone	Interspersion Index	Wildlife Value
I	21	3.1	2.2	n.a.	Disked for weed control or routinely farmed	1.0	Poor
II	3	4.0	*4.0	*20,800	31% cultivation; no consistent community	3.7	Low
III	14	33.6	3.2	500	Mostly cultivated; no consistent community	1.9	Low
IV	7	18.4	6.7	200	30% of soil zone occupied by 57% mesic forbs	6.0	High
V	1	27.4	5.5	0	Shortgrass community	1.0	Poor
VI	12	48.2	5.3	400	12% of soil zone in broad-leaved emergents; remainder in mesic forb community	4.8	Moderate
VII	3	45.2	9.8	21,000	All receive irrigation tailwater; wet meadow community over 33% of soil zone	5.7	High
VIII	9	62.7	6.1	700	Wet meadow on 55% of playas occupying 23% of soil zone	4.0	Moderate
IX	5	77.3	10.4	120	Broad-leaved emergent community on 60% of playas, occupying 13% of zone	2.8	Low
X	5	94.4	8.1	700	80% receive tailwater; wet meadow on 48% of soil zone	4.4	Moderate
XI	2	89.5	15.7	14,700	Aquatic and semi-aquatic plant communities on 70% of soil zone	4.0	Low-Moderate
XII	1	84.8	15.6	*37,500	80% cultivated; open water present	0.9	Low
XIII	4	107.4	14.8	3,200	Receive tailwater; wet meadow aquatic/semi-aquatic communities on 77% of soil zone	4.0	Moderate
XIV	2	115.3	9.1	300	Mesic forb community on 71% of soil zone	2.5	Low
XV	4	122.9	20.2	2,700	Wet meadow, mudflat, and open water communities on 40%, 13%, and 4% of soil zone, respectively	6.0	High
XVI	2	134.1	10.1	3,000	Receive tailwater; wet meadow, tall disturbed forb, and open-water communities	5.0	High
XVII	1	*150.0	*0.4	0	Entire zone cultivated	0.0	Poor
XVIII	2	154.9	17.5	4,700	Wet meadow and broad-leaved emergent, aquatic and semi-aquatic communities on 55% and 80% of soil zone	5.0	High
XIX	2	177.2	14.7	14,500	Open water, aquatic and semi-aquatic	6.0	High
XX	1	*261.3	*2.4	1,300	Five physiognomic communities from mesic to hydric with none exceeding 1 ha	7.0	High

*Distinctive playa attribute

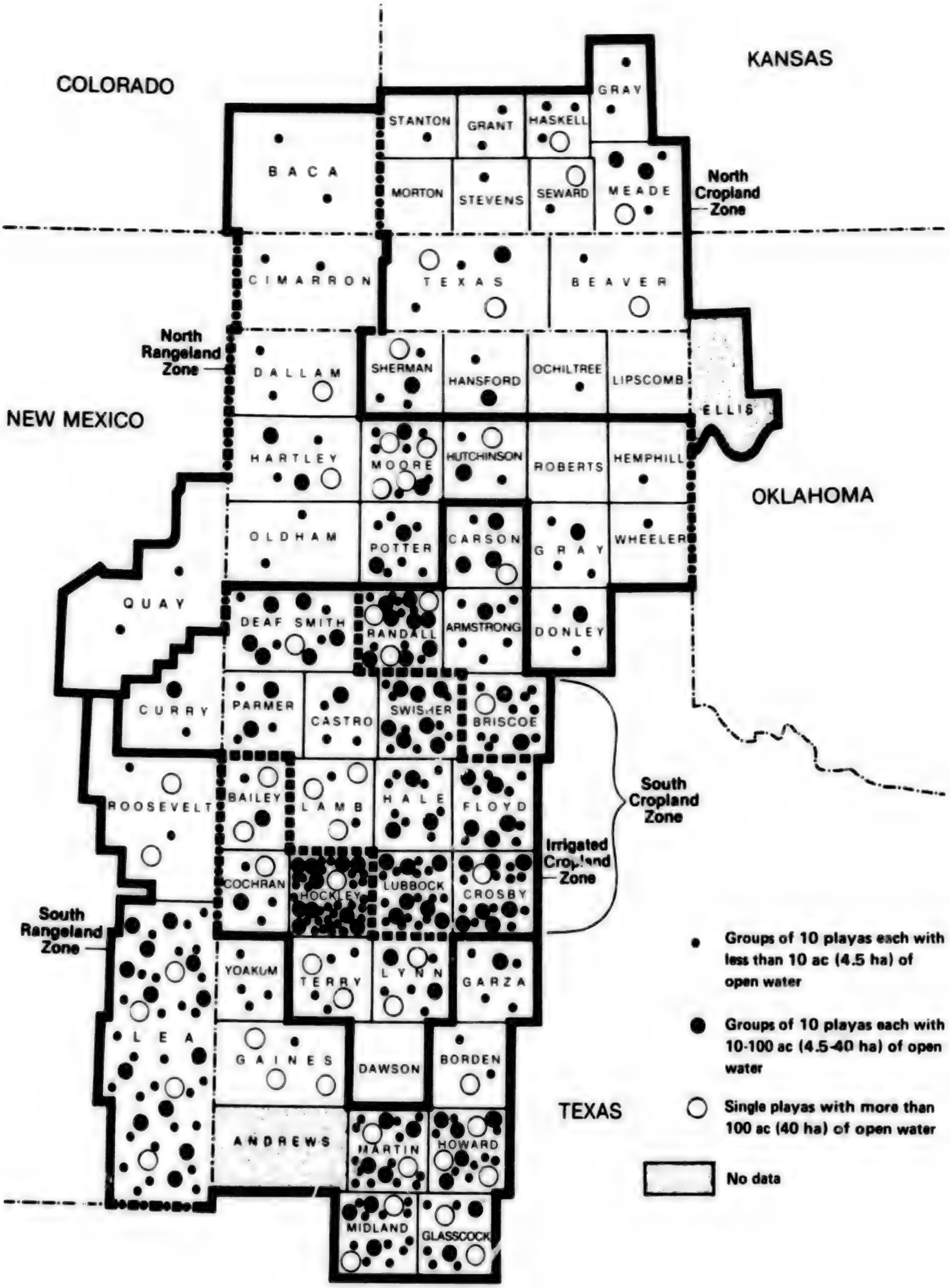

Figure 4-2. Wet-season distribution of playa lakes and wetlands by size classes based on surface area of open water (U.S. Bureau of Reclamation Playa inventory 1982).

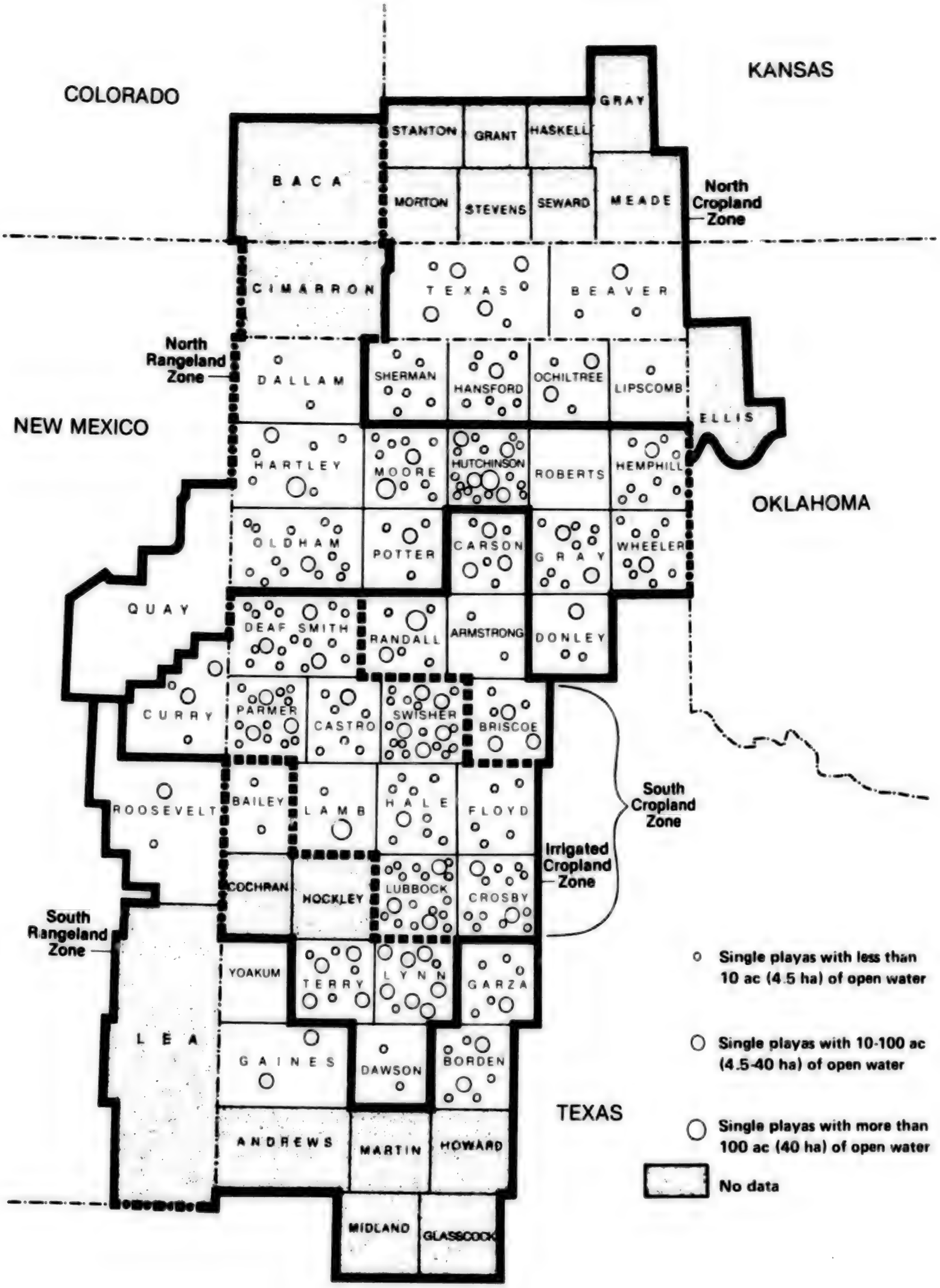

Figure 4-3. Dry-season distribution of playa lakes and wetlands by size classes based on surface area of open water (U.S. Bureau of Reclamation Playa inventory 1982).

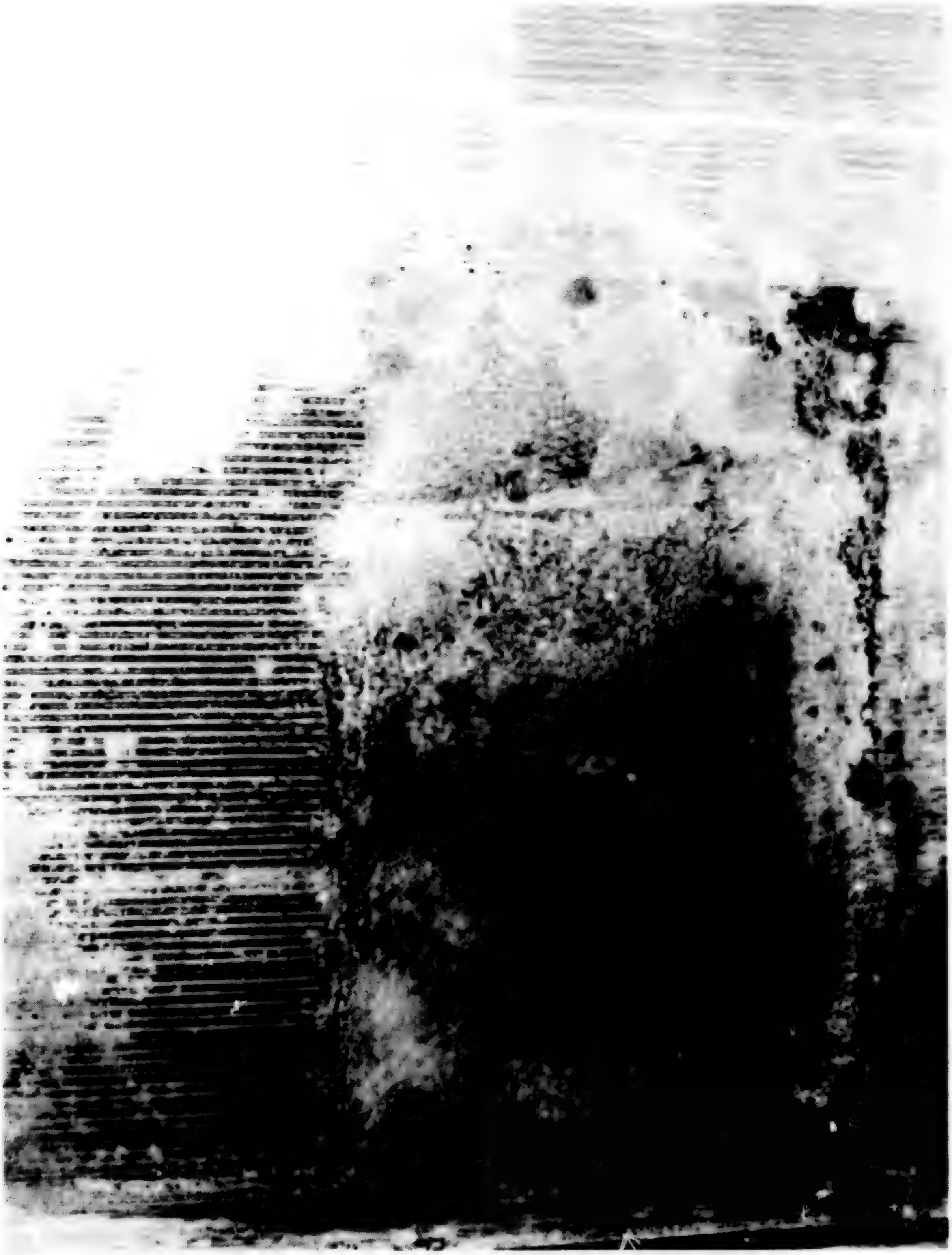

Figure 4-4. Agricultural playa, showing flooded crops and recovery of broad-leaved emergent as well as tall- and short-mesic forb communities. Photograph demonstrates the conflict existing between agricultural and wildlife habitat management goals (Texas Tech University, Department of Range and Wildlife Management 1981).

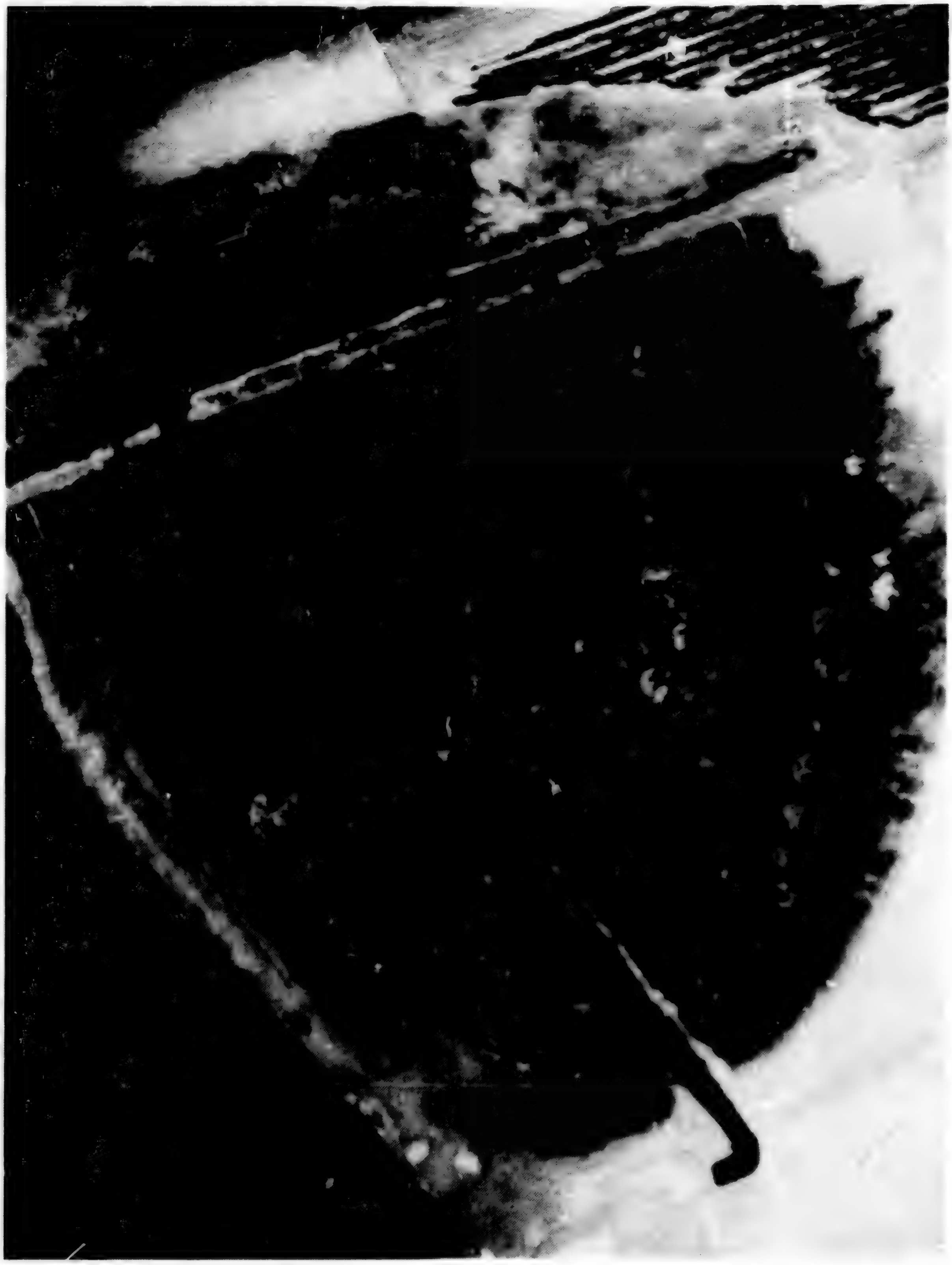

Figure 4-5. Cropland playa exhibits signs of past basin plowing, but has since been modified to collect and store irrigation tailwater. Wide variety of vegetation has become established, ranging from emergent aquatic plants to shrubs and trees having high interspersion, producing excellent wildlife habitat (Texas Tech University, Department of Range and Wildlife Management 1981).

Figure 4-6. Rangeland playa with a border of brush and tree species, habitat that enhances mourning dove and heron nesting. Playa has sufficient depth to support a catfish population (Nelson and Associates, Inc. 1981).

less than one-fifth of a 52-county study area (Figure 1-5).

Pates, Guthery and Stormer (1980) found that tailwater interception by playas was associated with increased plant species interspersion and, consequently, increased the value of wildlife habitat. Larger playa basins (>4 ha) promote better, more permanent wildlife values, as they tend to be cultivated less and have more persistent natural vegetation. Those basins that are unused and unmanaged may provide superior cover values for wildlife (Guthery 1981a). The variability of playa basins and their wildlife values based on physiognomic communities has been established (Table 4-7).

Variability and Diversity of Habitat. Playa water levels fluctuate during the year, depending on rainfall and land use; the pattern of fluctuations can influence the utility of playas for wildlife populations. Wildlife dependent on aquatic habitat tends to exhibit "boom or bust" fluctuations as a result of the variability of available water surface in playas (Bolen and Guthery 1982; Simpson and Bolen 1981). *Freshwater* playas produce a rather complex habitat used by resident and migratory wildlife for resting, feeding, and breeding. Use of *saline* playas by sandhill cranes is generally restricted to loafing and roosting; watering is provided at freshwater springs (Iverson and Vohs 1981).

The ephemeral nature of most playa wetlands seldom allows a stable flora. Playa basins may have a dense cover of annual and perennial terrestrial, semi-aquatic or aquatic vegetation, or may be barren, depending on the timing, intensity and amount of precipitation and irrigation runoff, the extent of grazing, and the size of playas. Vegetative and other attributes of playa basins that do and do not receive irrigation tailwater have been compared (Table 4-8). Tailwater recovery is associated with larger playas, greater coverage by plant communities, and higher interspersion of plant communities. A playa basin that has been modified to collect and store irrigation tailwater is likely to support emergent vegetation (Figure 4-7).

Playa basins may produce vegetative zonation (communities) in concentric bands from the basin center to the perimeter in response to decreasing water depths or soil moisture levels. The zonation increases habitat diversity and typically occurs at larger, unaltered playas (Guthery 1981b). The general sequence of vegetative zonation has been reported (Table 4-9) and illustrated (Figure 4-8). Such zonation is not typical of all playa basins; small playas that collect limited runoff may support prairie vegetation or may be cultivated. Except for the smartweed complex, the shallow, medium-size basins may be devoid of plant communities because of cultivation. The playa basins that are large enough to have an open expanse of deep water may have aquatic plant communities (Guthery 1981b).

Playa basin vegetation undergoes significant seasonal variation. Winter and early spring, which are normally dry, are the periods of greatest vegetative uniformity in playas (Ward and Huddleston 1972). Juen (1981) reported that playa vegetation is most critical for raccoons during these months when water, food and cover are scarce. Prior to winter and the first killing frost, playa vegetation going into dormancy is affected by rainfall from intense thunderstorms, input of irrigation tailwater, and the accumulated water volume in the basin. Gradual evaporation before the frost results in an after-frost cover of dense, dead vegetation that conserves soil moisture and protects emerging plants. Poor vegetative cover and attendant poor protection against wind erosion result in playa lake basins that dry out after the first killing frost (Ward and Huddleston 1972).

4.2 PLAYA BIRD POPULATIONS

The most common wildlife associated with playa basins is bird life. Simpson and Bolen (1981) reported pronounced changes

Table 4-7. Wildlife value of playa wetlands (n=101) in Bailey, Castro and Lamb Counties, Texas, based on physiognomic communities (after Guthery 1980).

Playa Type	Number in Sample	Mean Randall Soil Zone Area (ha)	Playa Code	Modification (if any)	Community Type and Extent of Randall Soil Zone Covered (%)	Mean Interspersion Index	Playa Wildlife Values
A	*40	2.73	D, P, *	Over 95% of Randall zone disked; 10% receive tailwater	General absence of physiognomic communities	0.48	Poor management potential
B	1	2.22	*	No tailwater	*Md. grs. (84%), Jhn. grs. (8%); Tr. shb. scattered groves increase interspersion	6.0	
C	3	2.71	D, P		Cult. (48%)	2.0	Poor managemtnt potential
D	3	4.43	H	Receive tailwater	Wt. mdw. (21%) Tl. dst. frb. (12%), Opn. wtr. (10%); total of 11 different plant communities	6.33	
E	1	6.32	H		Mdflt. (27%), Tl. dst. frb. (22%), Wt. mdw. (16%), Rd. pt. (4%), Tr. shb. (3%)	4.0	Suitable feeding habitat for shorebirds and others
F	1	6.05	P, *	Massively modified	*Spl. bnk. (35%), *Rd. pt. (30%), Cult. (30%)	4.0	Poor management potential
G	6	4.53			Msc. frb. (53%), Brd. lvd. emrg., Tl. dst. frb., Jhn. grs., Tr. shb., Rd. pt., Cult., Mdflt., Wt. mdw.	5.33	
H	3	8.73		Receive tailwater	Opn. wtr. (13%), Aqtc./Semi. aqtc. (42%), Dst. frb. (13%)	6.33	
I	4	5.31	D, *	Altered extensively; *disking perpetuates mudflats	Mdflt. (73%)	4.0	Suitable feeding habitat for shorebirds and others
J	3	6.45			Rd. pt., Cult., Wt. mdw. occur uniquely on each of the 3 playas	4.33	
K	3	6.05	H	80% of Randall soil zone cultivated in past	Brd. lvd. emerg. (40%), Cult. 33%	8.33	Wildlife value low due to extensive cultivation; excellent for ducks if shallow water is present
L	6	9.96	D	83% receive tailwater	Wt. mdw. (59%), Msc. frb. (9%), Opn. wtr. (5%), Spl. bnk. (5%), Tl. dst. frb. (4%)	5.7	Excellent feeding habitat for ducks if shallow water is present
M	4	8.89	D	Receive tailwater	Msc. frb. (62%), Dst. frb., Wt. mdw.	7.25	
N	1	5.51	*		*Occupied by shortgrass community	n.a.	Quality habitat for western meadowlark and black-tailed prairie dogs

Table 4-7. (concluded)

Playa Type	Number in Sample	Mean Randall Soil Zone Area (ha)	Playa Code	Modification (if any)	Community Type and Extent of Randall Soil Zone Covered (%)	Mean Interspersion Index	Playa Wildlife Values
O	4	11.9	D	Receive tailwater; grazing occurs	Brd. lvd. emrg. (41%), Wt. mdw. (9%), Sh. grs. (9%)	4.75	Excellent feeding habitat for ducks if shallow water is present
P	2	*18.75	H	Receive tailwater	Wt. mdw. (40%), Nr. lvd. emrg. (16%), Aqtc./Semi-aqtc. (82%)	6.0	Excellent due to large size; excellent feeding habitat for ducks if shallow water is present
Q	2	13.04	H		Msc. frb., Wt. mdw., Nr. lvd. emrg., Cult.; all in equal dominance	7.5	
R	5	12.05	D	Massive irrigation tailwater results in yearlong lake	Opn wtr. (63%), brd. lvd. emrg. (15%), Dst. frb. (10%)	7.0	Provide loafing habitat for waterfowl
S	2	14.92		Receive tailwater	Opn. wtr. (41%), Wt. mdw. (28%), Tl. dst. frb. (14%)	5.5	Provide loafing habitat for waterfowl
T	1	15.6	P, *	Massive modification	*Cult. (80%)	3.5	
U	2	15.73			Mdflt. (74%), Nr. lvd. emrg (14%)	n.a.	Suitable feeding habitat for shorebirds and others
V	4	21.19	D	Receive tailwater	Wt. mdw. (53%), Dst. frb. (10%), Msc. frb. (8%), Brd. lvd. emrg. (8%), Sh. brs. (7%)	5.0	Excellent feeding cover for ducks if shallow water is present

KEY

Playa Code

* - Distinctive playa attribute
D - Distinctive playa type
H - High wildlife management potential
P - Poor wildlife management potential

Community Abbreviations

Tr shb. - Tree shrub
Jhn. grs. - Johnsongrass
Md. grs. - Midgrass
Sh. grs. - Shortgrass
Cult. - Cultivation
Mdflt. - Mudflat
Tl. dst. frb. - Tall disturbed forb
Msc. frb. - Mesic forb
Brd. lvd. emrg. - Broad-leaved emergent
Nr. lvd. emrg. - Narrow-leaved emergent
Wt. mdw. - Wet meadow
Semi. aqtc. - Semi-aquatic
Aqtc. - Aquatic
Opn. wtr. - Open water
Spl. bnk. - Spoil bank
Rd. pt. - Road pit

Table 4-8. Comparative attributes of playas that do (n=60) and do not (n=41) receive irrigation tailwater in Bailey, Castro and Lamb Counties, Texas (Pates, Guthery and Stormer 1980).

Variable	Receives Tailwater $\bar{x}$ ± SE	No Tailwater $\bar{x}$ ± SE
Area (ha)		
Watershed	72.4 ± 6.79	30.7 ± 5.50
Randall soil	9.6 ± 0.73	2.7 ± 0.36
Broad-leaved emergents	1.0 ± 0.18	0.0 ± 0.00
Narrow-leaved emergents	0.3 ± 0.14	0.0 ± 0.00
Shortgrass	0.5 ± 0.17	1.3 ± 1.34
Johnsongrass	0.1 ± 0.04	0.0 ± 0.00
Open water	1.1 ± 0.31	0.0 ± 0.00
Mesic forbs	1.0 ± 0.23	0.0 ± 0.00
Wet meadow	2.2 ± 0.43	0.1 ± 0.10
Disturbed forbs	0.4 ± 0.17	0.0 ± 0.00
Community interspersion index	5.7 ± 0.27	0.3 ± 0.13

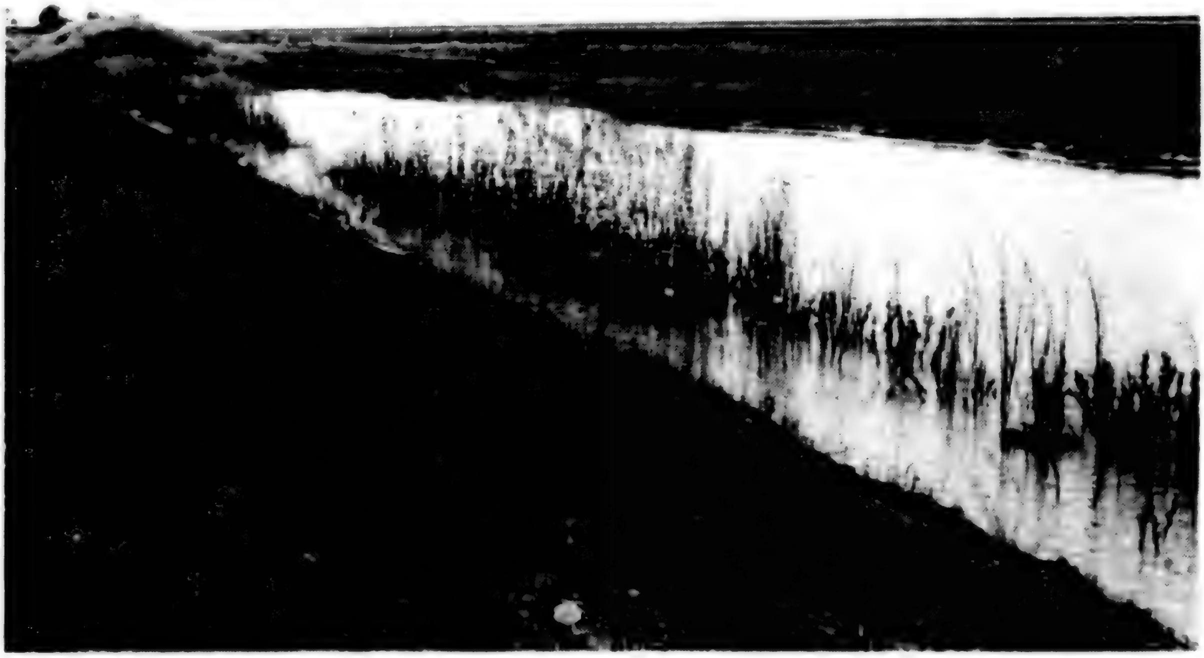

Figure 4-7. Emergent vegetation in a playa basin that is modified by excavation and diking to collect and store irrigation tailwater for subsequent recycling (Nelson and Associates, Inc. 1981).

Table 4-9. General sequence of vegetative zonation found at the larger, unaltered playas (various sources).

Dry Uplands	Moist Perimeter	Moist Interior	Intermittently Flooded Center	Permanently Flooded Center
Blue grama[1]	Barnyardgrass[1]	Devilweed aster[1]	Cattail[1]	Muskgrass[1]
Western wheatgrass[1]	Buffalograss[2]	Spikerush[1]	Bulrush[1]	Wigeon grass[1]
Silver bluestem[1]	Gray ragweed (stunted)[2]	Gray ragweed[1]		Pondweed[1]
Buffalograss[3]	Lambsquarters[2]	Smartweed spp.[1]		
Crops[3]	Crops[3]	Cocklebur[2]		
		Curly dock[4]		

References:
[1] Guthery 1981b
[2] Guthery 1980
[3] Bolen 1980
[4] Rollo and Bolen 1969

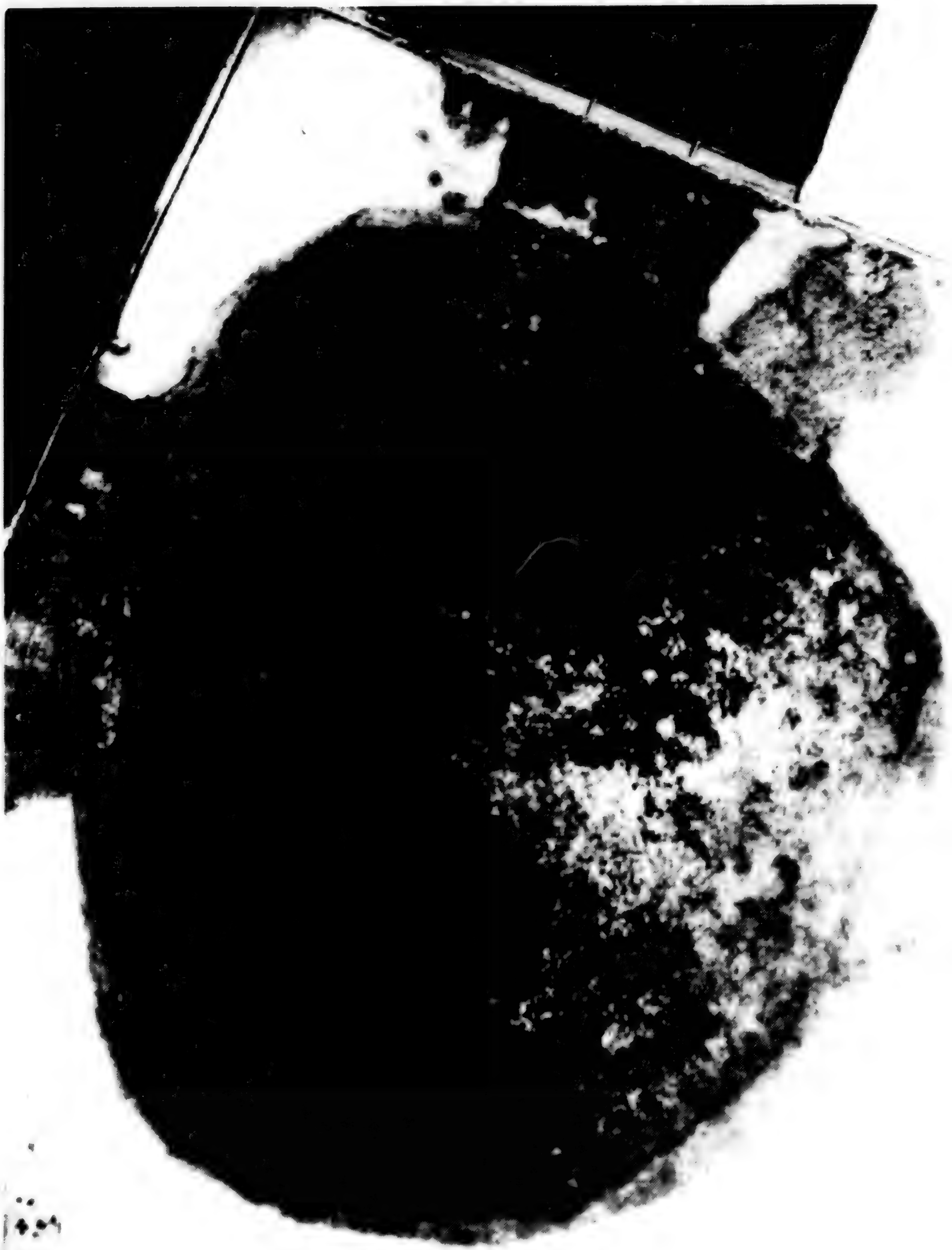

Figure 4-8. Playa basin supports broad-leaved emergents, wet meadow, and shortgrass prairie which are enhanced by interception of irrigation tailwater, providing good wildlife habitat. Playa has roughly concentric vegetative zonation, affording greater habitat diversity (Texas Tech University, Department of Range and Wildlife Management 1981).

in species composition appearing among seasons. Curtis and Beierman (1980) observed from a limited sample that, although playa habitats might be expected to be dominated by shorebirds and waterfowl, actually the terrestrial bird species appeared to occur in higher frequency and variety. Some of the more common or abundant birds associated with playas in Castro, Parmer and Swisher Counties, Texas, have been listed (Table 4-10) along with their expected season of use. This identification may not be representative for the study region as a whole. (A more complete checklist of playa bird species is contained in Appendix B.)

Waterfowl at Playa Basins. Over one million ducks and other waterfowl have been sustained in the Southern Great Plains playa region during winter, given adequate moisture (Buller 1964). Simpson et al. (1981) noted that 20 migratory bird species used Castro County, Texas, playas during winter and eight migratory game bird species breed in the area. The Southern Great Plains has a winter sandhill crane population exceeding 300,000 (Bolen 1980). Confirmed sightings of whooping cranes, an endangered species, occurred at playa lakes in Carson County in 1965 and 1973 (Curtis and Beierman 1980), but there is no evidence of overwintering. Regional duck production is low compared to other Central Flyway areas although, in some years, brood production can be significant, especially for mallards (Bolen and Guthery 1982). Weller (1964) recorded production of redheads (overwater nesters) at playas. This is noteworthy, considering the decline in redhead numbers in the rest of the Central Flyway.

Migratory waterfowl numbers in Castro County, Texas, follow a progression from late August through November with two peaks occurring; one is in late November through December and the other in February (Simpson et al. 1981). Traweek (1981) reported a peak in winter resident populations of ducks and geese at playa basins during December and January, their presence being a function of open water resulting from runoff of irrigation tailwater and some snow melt. Lack of open water in playas causes waterfowl to shift to the larger, man-made reservoirs of the region, or to migrate farther south. Moore (1980) regarded the February peak of waterfowl numbers as indicative of northbound spring migrants. March-April marks a decline in playa waterfowl numbers as migrants leave the region with most departing by mid-April.

The winter waterfowl survey of the Texas High Plains covered four major species of puddle ducks during the period 1974-1981 (Table 4-11). Mallards are particularly numerous in the Southern Great Plains along the Central Flyway. Because mallards of the region were generally underharvested, judging from high survival rates, the High Plains Mallard Management Unit was formed (Funk et al. 1971). This unit presides over waterfowl management in the playa lake and wetland region, and has promulgated more liberal harvest regulations covering mallards and other species.

Other Birds at Playa Basins. Other birds associated with playas include upland game such as bobwhite and scaled quail, mourning dove, and particularly ring-necked pheasant. Shore and wading birds observed include avocets, curlews, plovers, egrets, herons, and ibis. Passerines include orioles, robins, sparrows, thrushes, warblers, and wrens; red-winged and yellow-headed blackbirds are common (Beierman 1982). Jones and Felts (as cited in Bolen and Guthery 1982) reported that, around 1940, ring-necked pheasants became established in the Texas Panhandle; since then, 33 counties have been colonized with pheasants closely linked to playa habitats (Guthery, Custer and Owen 1980). Taylor and Guthery (1979) observed high densities of mourning dove nests in playa basin communities, ranging from 1.9 to 8.2 nests per hectare. Red-winged and yellow-headed blackbirds were the most abundant breeding birds of playa lakes and wetlands. Their nests were confined mainly to the

Table 4-10. Common (C) or Abundant (A) bird species associated with playa basins and their typical season of use in Castro, Parmer and Swisher Counties, Texas (Simpson and Bolen 1981).

Black-crowned night heron	(A)	Resident
Swainson's hawk	(A)	Spring and fall migrant
Northern harrier	(A)	Spring and fall migrant; winter resident
Ring-necked pheasant	(A)	Resident
American coot	(C)	Spring and fall migrant; summer resident
Killdeer	(A)	Spring to fall resident
Long-billed curlew	(C)	Fall migrant
Upland sandpiper	(C)	Spring and fall migrant
Greater yellowlegs	(C)	Spring and fall migrant
Lesser yellowlegs	(A)	Spring and fall migrant
Baird's sandpiper	(C)	Fall migrant
Least sandpiper	(A)	Fall migrant
Western sandpiper	(C)	Fall migrant
Long-billed dowitcher	(A)	Spring and fall migrant
American avocet	(A)	Spring and fall migrant; summer resident
Wilson's phalarope	(A)	Spring and fall migrant
Black tern	(C)	Spring and fall migrant
Mourning dove	(A)	Spring to fall resident
Burrowing owl	(C)	Spring and fall migrant; summer resident
Short-eared owl	(C)	Winter resident
Western kingbird	(C)	Spring and fall migrant; summer resident
Horned lark	(A)	Resident
Tree swallow	(C-A)	(C) spring; (A) fall migrant
Barn swallow	(A)	Spring and fall migrant
Cliff swallow	(A)	Spring and fall migrant
Common crow	(A)	Winter resident
Starling	(C)	Resident
House sparrow	(A)	Resident
Western meadowlark	(A)	Resident
Yellow-headed blackbird	(A)	Spring and fall migrant; summer resident
Red-winged blackbird	(A)	Resident
Great-tailed grackle	(C)	Spring and fall migrant; summer resident
Brown-headed cowbird	(C)	Spring and fall migrant; summer resident
Lark bunting	(C)	Spring and fall migrant
Savannah sparrow	(C)	Spring and fall migrant; winter resident
White-crowned sparrow	(A)	Spring and fall migrant; winter resident
Chestnut-collared longspur	(C)	Winter resident

Table 4-11. Texas High Plains winter waterfowl censuses of four major species of puddle ducks as derived from Texas Parks and Wildlife Department surveys, 1974-1981, by Simpson and Bolen (1981).

Year	Mallard	Pintail	Wigeon	Green-winged Teal	All Puddle Ducks*
1974-75	457,225	855,700	121,850	94,457	1,529,482
1975-76	309,663	151,688	55,977	25,443	546,400
1976-77	407,920	247,040	90,000	53,040	798,200
1977-78	76,350	72,450	21,400	24,150	194,650
1978-79	249,500	50,900	11,400	4,100	315,900
1979-80	191,900	191,600	64,200	19,600	467,500
1980-81	166,100	105,500	42,400	18,300	332,200

*Includes small numbers (<4,000) of gadwall, shoveler and other species, except for 1980-81, when 42,400 gadwall were included in the total; even smaller numbers (<400) of diving ducks (*Aythya* spp.) were counted but are not reported here.

playa basins (Fischer and Bolen 1981); Simpson and Bolen 1981).

Various birds of prey inhabit, overwinter or breed in the Southern Great Plains. Simpson and Bolen (1981) reported that most raptors are observed in the region during the winter, with the exception of the Swainson's hawk, a summer resident. The northern harrier or marsh hawk is the most common raptor associated with the playa environment. Other predatory birds observed are roadrunners, owls, falcons, and eagles (Beierman 1982). Bald eagles, an endangered species, winter in the Texas Panhandle, using playa lakes as feeding stations. One playa in Hutchinson County was reported having a concentration of 58 bald and golden eagles in the winter of 1978-79 (Curtis and Beierman 1980).

Importance of Playas to Birds. Playa basins have provided the second most important habitat for winter waterfowl in the Central Flyway, exceeded only by the Gulf Coast (Buller 1964). Bellrose (1976) regarded the playas as the most important wintering area in the Central Flyway for green-winged teal. Playas that contain water provide valuable watering, roosting, loafing, and foraging sites, often in close proximity to feeding fields (Rutherford 1970). Moore (1980) recognized the importance of open water in playas, especially during winter when freezing takes place; lakes with open water have greatest duck use, with large concentrations appearing on the ice near small areas of open water. Playas containing water may support up to 90% of the Texas Panhandle wintering waterfowl population (Curtis and Beierman 1980).

Table 4-12. Nest densities (no./ha) by habitat of ring-necked pheasants in Castro County, Texas, 1979-1980 (Taylor and Guthery 1980).

Habitat	1979	1980	Average
Playa Basins	2.45	1.99	2.21
Alfalfa Fields	1.58	1.58	1.58
Wheat Fields	1.76	1.23	1.49
Roadside Strips	2.65	0.23	1.44
Rye Fields	1.23	0.00	0.61
Oat Fields	0.08	0.54	0.31

Cover and food provided by playas are of particular importance to migrating, overwintering and resident waterfowl, as well as terrestrial birds. Vegetation of particular importance to blue- and green-winged teal as cover and food is generally restricted to lake margins (Rollo and Bolen 1969). During winter, playa cover is most critical to pheasants because of a lack of alternative cover; pheasants mass in this habitat during this season, spending up to 90% of the time in playa cover (Bolen and Guthery 1982). Wild millet, smartweed, snails, and insects are some of the foods that birds may consume in playa environments.

Playas and the cover they afford are particularly important during late winter and in spring as breeding grounds for endemic waterfowl and terrestrial birds (Rhodes 1978). During this period, several species of ducks actively pair and breed (Traweek 1981). Mallard, redheads, pintails, cinnamon teal, and blue-winged teal are the more abundant waterfowl species that breed in playa habitats. Mallards are typically the most abundant breeding species and may comprise over 80% of duck broods produced at playa lakes (Simpson and Bolen 1981; Traweek 1978). Playas also provide a large proportion of the nesting cover required by ring-necked pheasants; average clutch size, percentage nesting success, and chick production per unit of area are usually higher in playas than in other types of cover (Taylor and Pence 1981). Several types of habitat are used by pheasant for nesting; nest densities vary by habitat type (Table 4-12).

Habitat Preferences of Selected Species. According to Moore (1980), some species such as pintails prefer large playas with open water and little emergent vegetation (Figure 4-9), while others such as mallards may congregate at smaller playas having moderate emergent vegetation (Figure 4-10). Salt playas may be avoided for nesting and feeding, but may be used extensively for resting, roosting and staging by sandhill cranes (Iverson and Vohs 1981). Nesting habitats provided within the basins may be the major attraction for both resident and migratory species such as sparrows, blackbirds, mourning doves, and mallards. Trees that volunteer or are planted as windbreaks, and man-made structures such as dikes may increase diversity of nesting sites. The cover produced in these areas is responsible for larger concentrations of prey species hunted by harrier hawks, and is also important for overwintering birds including the resident pheasants. Different playa habitat features are important to selected bird species (Table 4-13).

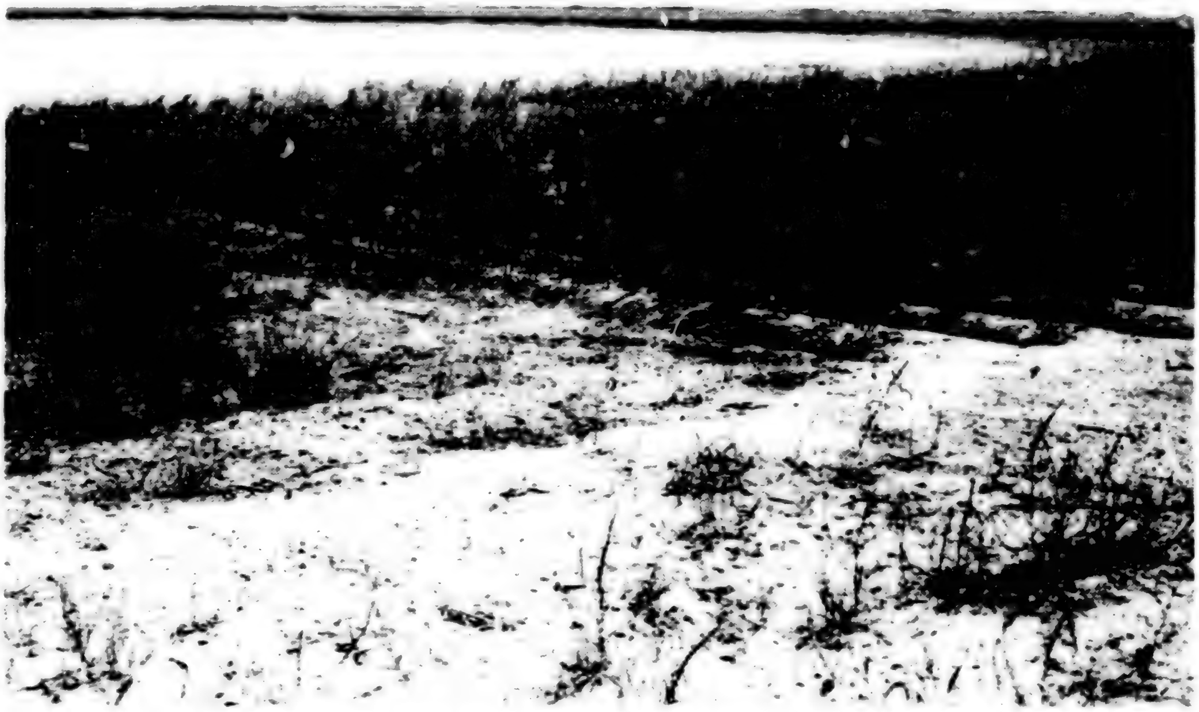

Figure 4-9. Agricultural playa lake contrasting shoreline brush with cotton production. According to Moore (1980), large lakes of this kind having little emergent vegetation are often preferred by ducks such as pintails (Nelson and Associates, Inc. 1981).

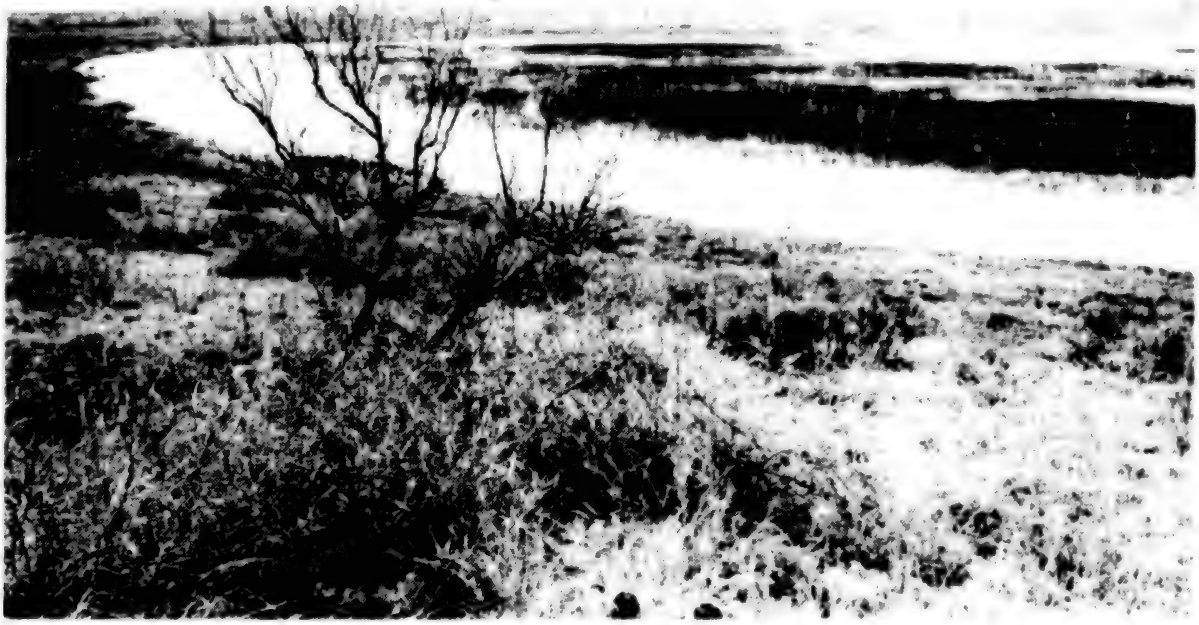

Figure 4-10. Rangeland playa with moderate emergent vegetation. According to Moore (1980), this type of playa wetland may be preferred by mallards for roosting; it is also important to brooding hens (Nelson and Associates, Inc. 1981).

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Table 4-13. Playa habitat features used by selected bird species (various sources).

Species	Habitat Use	Additional Information	References
Ducks (generally)	Overriding factor in playa use is availability of open water; playas modified to hold water year-round are used heavily	Playas preferred for nesting, followed by roadside cover, alfalfa fields, and wheat fields	Moore 1980; Taylor and Guthery 1980
Mallards	Small- to medium-size playas where open water is interspersed with patches of emergent vegetation	Open areas used for loafing	Simpson et al. 1981; Moore 1980
Pintails	Large playas with open water, sparsely covered with emergent vegetation, and having bare shorelines	Open areas used for loafing	Simpson et al. 1981; Moore 1980
Teal	Playas with relatively shallow water	Used for loafing and feeding	Moore 1980
Wigeons	Playas with large areas of open water, with or without shoreline vegetation	Open areas used for loafing	Moore 1980
Coots	Cattail thickets	Used as nesting sites	Simpson and Bolen 1981
Canada geese	Large- to medium-size playas with open water	Playas preferred in close proximity to grain fields	Huey 1967
Sandhill cranes	Saline playas for resting and staging free from predators; smaller freshwater playas for feeding and drinking	Freshwater inflows from springs surrounding saline playas used as drinking water	Iverson and Vohs 1981; Pence 1981; Huey 1967
Black-crowned night herons	Willow stands	Used as nesting sites	Simpson and Bolen 1981
Avocets	Playas with shallow open water used for feeding	Dikes constructed through playas used as nesting sites	Simpson and Bolen 1981

Table 4-13. (concluded)

Species	Habitat Use	Additional Information	References
Harriers	Cropland playas having tall vegetation preferred over range playas	Preferred feeding sites offer more cover for rodents and other prey	Simpson and Bolen 1981
Ring-necked pheasants	Residual cover preferred (cattails, bulrush, kochia); cattails preferred for roosting; playas used for travel lanes, nesting and overwinter cover	Majority nest in playas before June 1; use croplands during spring, summer and fall; playa winter cover essential during winter	Bolen and Guthery 1982; Guthery 1981b; Taylor and Guthery 1980; Bolen 1980; Owen and Guthery 1979
Mourning doves	Cattail thickets and weed-choked shorelines; tree thickets	Used for nesting and resting; greatest nest density found at playas with trees	Simpson and Bolen 1981; Ward and Huddleston 1972
Red-winged blackbirds	Playa cattails or bulrush for nesting, usually over water; also nesting in dock	Playas used more for nesting by this species (and yellow-headed blackbirds) than any other	Simpson and Bolen 1981; Taylor and Guthery 1979
Great-tailed grackles	Willow stands	Used for nesting cover	Simpson and Bolen 1981
Sparrows	Weed-choked shores of playas	Used for feeding and resting	Ward and Huddleston 1972

4.3 OTHER WILDLIFE POPULATIONS AND INVERTEBRATES

Certain mammals, reptiles, amphibians, fish, and invertebrates are linked to playa environments. Concentration of water that provides a drinking source and promotes cover in a relatively dry, barren region is a prime factor in promoting the variety of other wildlife populations and invertebrates that inhabit playa basins.

Mammals of Playa Basins. Many large and small mammals, including some predators, are attracted to playa basins; cropland playas are particularly attractive (Figure 4-11). Pronghorn antelope, mule deer, and white-tailed deer are examples of large mammals that sometimes use playa habitats. At one time, the Texas High Plains was a region of pronghorn abundance (Leftwich and Simpson 1977). Their large numbers were tied to the surface waters found in draws and basins, as well as the integrity of the shortgrass prairie ecosystem (Bolen, Simpson and Stormer 1979). Simpson and Bolen (1981) reported that present populations of pronghorns occur in small groups on the larger ranches of the Southern High Plains (Llano Estacado). Mule deer of the region tend to congregate in the broken hill country, while white-tailed deer are generally found in the plains brushlands. Playa basins may be used by deer as a source of food and water.

Rodents and lagomorphs depend on playas for refuge and food, especially in the agriculturally intensive areas. These small animals are confined for the most part to the playas, draws, rangelands, and weedy areas throughout the farmed fields (Simpson and Bolen 1981; Curtis and Beierman 1980). Ragweed and kochia supported the highest density and diversity of small mammals; deer mice were the most common species encountered, followed by 13-lined ground squirrels and house mice (Simpson and Bolen 1981). In addition to jackrabbits, desert and eastern cottontails frequently are observed in playa basins; playas having permanent cover contribute a substantial portion of their diet (Simpson and Bolen 1981; Scribner and Krysl 1980). The size of the playa lake or wetland, water availability, and types of vegetation largely govern the population size and species composition of small mammals found within the basin.

Predators linked with playas include coyotes, badgers, raccoons, weasels, swift foxes, skunks, and oppossums. Coyotes frequently are sighted in or adjacent to playas where their needs for food, water and cover are satisfied. Whiteside and Guthery (1981) noted the high availability and diversity of playa food sources preferred by coyotes. Badger dens commonly are excavated from earth banks in modified playas or on the periphery of the unaltered basin; generally they are associated with rangeland playas (Simpson and Bolen 1981). Raccoons along with coyotes are the dominant furbearers of the playas (Curtis and Beierman 1980). Those playas containing dense vegetation and cover are preferred by raccoons; nearly 70% of their den sites are located within the basins of playas containing thick cover (Juen 1981). (A checklist of mammals that inhabit playa basins is found in Appendix C.)

Reptiles, Amphibians, and Fishes. Curtis and Beierman (1980) reported that, although reptiles are not commonly observed, amphibians are a typical resident of playa habitat. Except for Rose and Armentrout (1975), there has been little study of playa herpetology. Some of the more familiar reptiles observed around playa basins include the southern prairie lizard, Texas horned lizard, Great Plains skink, checkered garter snake, blotched water snake, western hognosed snake, yellow mud turtle, and western diamondback rattlesnake. Amphibians of the Southern Great Plains have a critical need for the aquatic habitat of playa basins. Following spring rains, breeding in playa wetlands reaches a peak, producing large numbers of young amphibians. Commercial harvest of salamanders and newts at playa basins is rare.

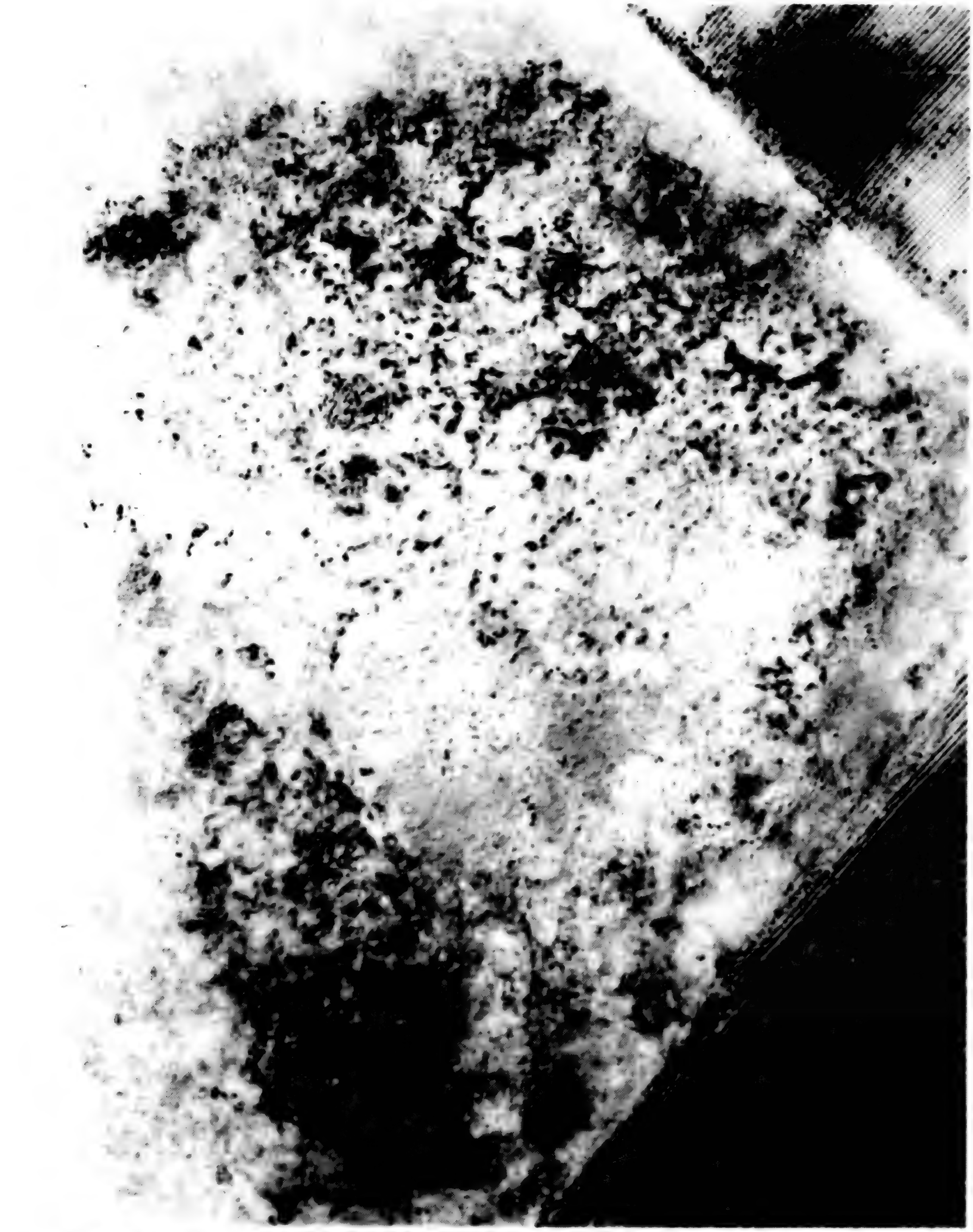

Figure 4-11. Cropland playa supporting a mix of wet meadow, tall disturbed forbs, and short- to mid-grass vegetation, yielding good wildlife values. Plowing does not heavily encroach upon the playa basin, allowing native vegetation to flourish and provide cover for many varieties of wildlife (Texas Tech University, Department of Range and Wildlife Management 1981).

Examples of amphibians associated with playas include eastern tiger salamanders, spadefoot toads, and leopard frogs.

Fisheries of playa lakes are quite limited; most lakes are uninhabited by fish (Curtis and Beierman 1980). Some of the larger playa lakes that hold water year-round have been stocked for sport fishing. Other, more ephemeral lakes have been stocked on a temporary basis for the purpose of mosquito control. Some of the species introduced into playa lakes include bluegill, goldfish, largemouth bass, black bullhead, channel catfish, carp, and golden shiner. A playa permanently flooded as a result of collecting both irrigation tailwater and feedlot runoff could be a good candidate for aquaculture because of the nutrient enrichment (Figure 4-12). (A further listing of reptiles, amphibians, and fish associated with playa environments is provided in Appendix D.)

Invertebrates of Playa Basins. Sublette and Sublette (1976) noted the importance of invertebrate production in playa basins to their basic food chains; the variety of species and their abundance is as diverse as the playas, depending on the character of playa vegetation. Rhodes and Garcia (1981) observed significantly higher insect production at unmodified playas as compared with modified basins. Over 60 species of macroinvertebrates were collected from two playas near Lubbock, Texas, by Merickel and Wangberg (1981). The most well-known invertebrate produced in playa lakes and wetlands is the mosquito. A playa is a prime environment for mosquito breeding, resulting in extensive efforts directed towards mosquito control (Lubbock City-County Health Unit 1962). Examples of other invertebrates produced in playa basins include fairy shrimp, snails, leeches, water striders, mayflies, bees, and grasshoppers. (A more extensive list of invertebrates found in playas is furnished in Appendix E.)

4.4 WILDLIFE DISEASES ASSOCIATED WITH PLAYAS

Thousands of waterfowl and other wildlife are lost each year to diseases that are endemic to playa basins. Biotic, climatic, physical, and land use factors combine to create and perpetuate conditions that promote encephalitis, avian cholera, botulism, and duck schistosomiasis.

St. Louis encephalitis and western equine encephalitis, arbovirus diseases, are endemic to the Southern Great Plains, causing periodic outbreaks in wildlife populations (Pence 1981). Avian or fowl cholera, a highly pathogenic bacterial disease caused by *Pasteurella multocida*, is also endemic to the region. This disease was first reported in wild ducks during a 1944 epidemic at the Muleshoe National Wildlife Refuge in the Texas Panhandle (Quortrup, Queen and Merovka 1946). Jenson and Williams (1964) reported that botulism, an extremely pathogenic bacterial disease caused by *Clostridium botulinum*, occurs seasonally in some playa basins. Another playa-associated disease, duck schistosomiasis, affects a great many waterfowl. The disease is caused by a parasitic blood fluke and is highly pathogenic to young birds.

Factors Contributing to Disease. Several factors contribute to the transmission of playa disease organisms to wildlife. Disease may be present in the soil or water and in host organisms, and reservoirs of infection may be present among birds already diseased. Large numbers of animals congregating at relatively small sites enhance disease transmission. Irrigation practices and climate may produce water fluctuations and broad expanses of shallow water, all of which contribute to the periodicity and endemic nature of these epizootics.

The two varieties of arboencephalitis found in the Southern Great Plains have a common vector in the mosquito, *Culex tarsalis* (Grubb, Parks and Sciple 1968). The

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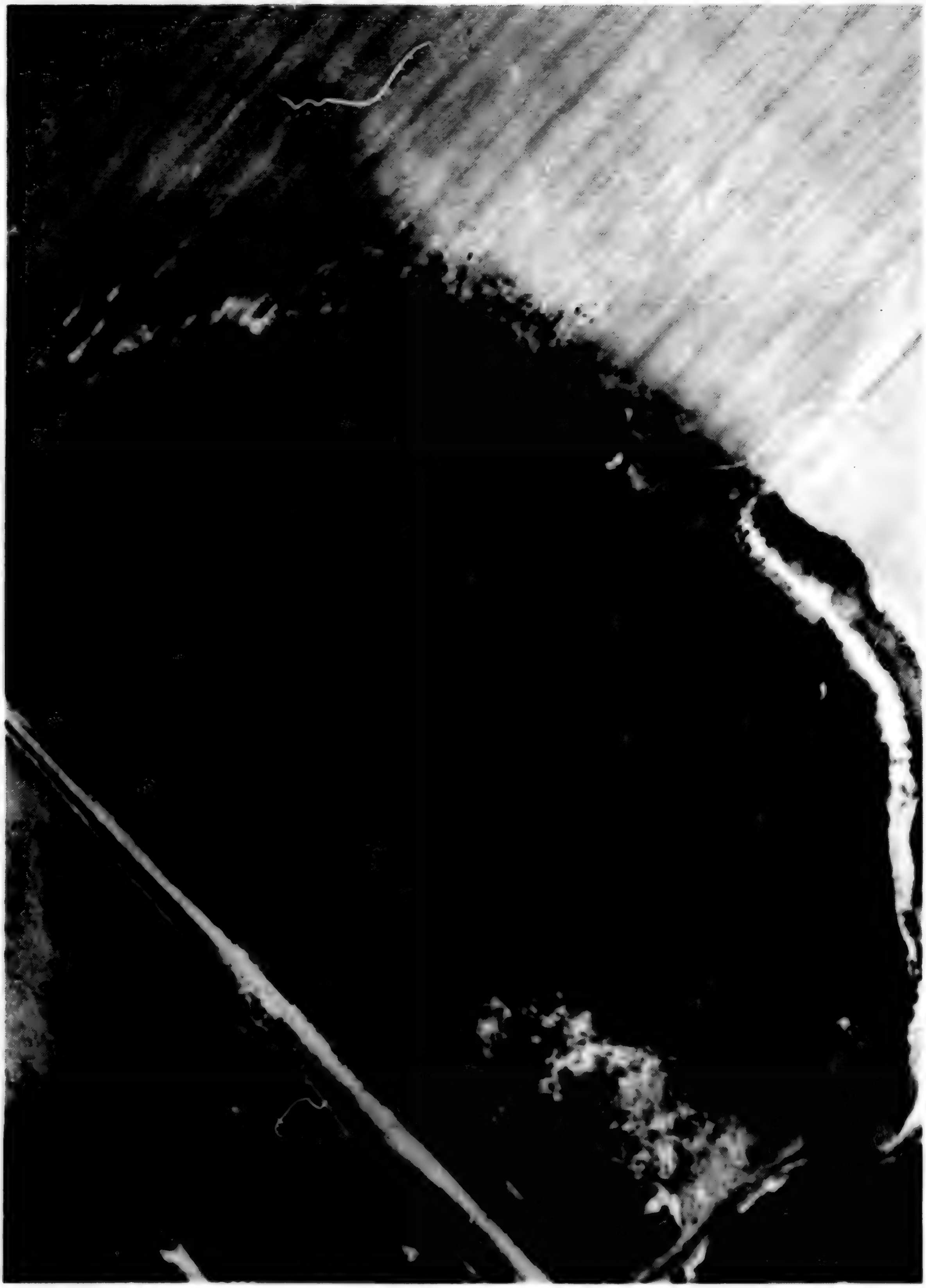

Figure 4-12. Agricultural playa with permanent open water, resulting from collection of irrigation tailwater and feedlot runoff, will support aquaculture and other aquatic life (Texas Tech University, Department of Range and Wildlife Management 1981).

warm shallow water of playa lakes provides superior breeding habitat for *C. tarsalis*; playas are reported to produce 75% of Texas High Plains mosquitos (Harmston et al. 1956). A major factor influencing mosquito populations is the frequency of water level fluctuation; numbers of mosquito larvae increase with elevated water levels, and adult mosquito numbers increase as water levels decline (Ward and Huddleston 1972). Additionally, water inputs from irrigation and seasonal rainfall in June and July induce lush vegetative growth that provides excellent habitat for the first generation of mosquitos. A second peak of mosquito production occurs in late summer due to compounding the breeding success of the previous generations (Ward and Huddleston 1972). The encephalitis virus is easily carried through the winter in the major known reservoir of wild birds, including prairie chicken and pheasant (Grubbs, Parks and Sciple 1968).

Avian cholera is observed most frequently during winter when playa lakes are frozen, forcing large numbers of waterfowl to concentrate on small patches of open water and mixing sick and healthy birds (Moore 1980). Common crows act as reservoirs of fowl cholera by feeding on infected carcasses and perpetuating the disease (Taylor and Pence 1981).

Outbreaks of botulism at playa basins usually occur during the late summer and early fall. Factors responsible for the Type C botulism of the playa region are: presence of the bacteria *C. botulinum* that produces the lethal toxin; flooding of agricultural land that promotes expanses of shallow water over organic-rich sediments, resulting in anaerobic conditions; and high temperatures that warm the sediments (Pence 1981). Also, macroinvertebrate carcasses must be present. Waterfowl and other wildlife that ingest macroinvertebrates containing the bacterial toxin have little chance of survival, and playas possessing a favorable environment tend to have regular die-offs.

Infestation of duck schistosomiasis tends to be chronic at affected playas as well. Infected snails breeding in the playa mudflats act as an intermediate host for the blood flukes, resulting in a long-term disease source. Waterfowl act as definitive hosts for this blood fluke, becoming infected when they eat the snail. Transmission of schistosomiasis from playa to playa when fluke eggs are released in bird feces allows the next life stage (miracidium) to infect snails. Miracidia may also attack humans, causing a form of "swimmers' itch" (Noble and Noble 1974).

Effects of Disease on Wildlife. Losses of wildlife, particularly waterfowl, to disease pose a substantial non-hunting mortality problem that is significant to the regional waterfowl population dynamics (Bolen 1980; Moore 1980). The loss of ducks to disease was estimated to be nearly three times the number of ducks harvested during the hunting season (Moore and Simpson 1980). Two die-offs in the region occur each year, the first in late summer (botulism) and the second in winter (avian cholera) (Moore and Simpson 1980). Over 60,000 birds were lost to cholera in the Muleshoe, Texas, area during the winter of 1956-57 (Jenson and Williams 1964). Moore and Simpson (1980) estimated that bird losses to disease exceeded 60,000 in the Castro County, Texas, area during the winters of 1977-78 and 1978-79.

5.0 PLAYA USES AND MODIFICATION

The principal use of playas is to augment irrigation water supplies by storing natural runoff and irrigation tailwater to supplement the pumping of groundwater. An allied use is the watering of livestock, and some playa water has been used for aquifer recharge. Planting of crops and grazing of livestock in all or part of the playa basin is widespread. Hunting is the main recreational use of playas, particularly for migratory waterfowl. The use of playas for impounding feedlot waste is common, and a small number of basins are used to dispose of oil field brine and municipal sewage effluent. Playa modifications, specifically excavation and diking, are made to increase irrigation water storage by reducing evaporation, as well as to assist aquifer recharge and control mosquitoes and disease. In the face of declining aquifer reserves in the Texas High Plains, the trend in modifications is downward except where irrigation is still expanding.

5.1 AGRICULTURAL WATER SUPPLY

The playas of the Southern Great Plains were used by Indians and early explorers as a water supply. In the ranching era, before irrigation was common, they were used primarily to water livestock, which is still a major use of playas (Templer 1978). Estimates of the total number of playas, both modified and unmodified, that are used for this purpose are not available. Obviously, many rangeland playas are used at least to some extent for this purpose (Figure 5-1).

Figure 5-1. Watering of livestock at an unmodified playa basin in the Texas High Plains (Nelson and Associates, Inc. 1981).

Table 5-1. Percentage of playa basins excavated to concentrate water for livestock use, by zones of the study region (Guthery et al. 1981).

	Playas Excavated	
	No.	%
North Cropland Zone	52	10
North Rangeland Zone	81	21
South Cropland Zone	123	19
Irrigated Cropland Zone	183	35
South Rangeland Zone	31	10
Study Region	470	20

Some rangeland playas are modified with small excavations to concentrate water for livestock use. This type of alteration probably accounts for nearly one-third of all modifications of playas that do not receive irrigation tailwater (Guthery et al. 1981). The proportion of *all* playas modified for this purpose is highest in the Irrigated Cropland Zone (Table 5-1). The alteration of playas for livestock watering is twice as prevalent at playas having over 10 ac (4 ha) of surface area as compared to those under 10 ac (Guthery et al. 1981).

Irrigation Water Storage. The impoundment of natural runoff within playa basins of the Southern Great Plains can make a significant contribution to water reserves for irrigation of croplands (Figures 5-2 and 5-3). According to Aronovici, Schneider and Jones (1970), and to Palacios (1981), estimates of the natural runoff collecting in playas range from 2 to 8 x 10^6 ac-ft/yr (2.5-9.9 x 10^9 m^3/yr), or the equivalent of one-fourth to all of the water pumped annually from the Ogallala Aquifer in the study region. The use of playa water for irrigation lowers pumping costs and reduces withdrawals from the Ogallala Aquifer.

Suspended sediments in playa water pose no problem for irrigation (Dvoracek 1981). Several factors, however, influence playa water use, including the timing of natural runoff, length of time that water can be stored, water-holding capacity of cropland soil, and optimum irrigation scheduling (Hauser 1968). The major drawback to the use of playa water for irrigation has to do with timing. It is generally difficult to predict when playa basins will be filled; in a dry year, lake water may be unavailable during the growing season (Templer 1978). Except for the runoff resulting from sudden rainstorms, the availability of accumulated runoff in playas usually follows a rainy season when cropland soils become saturated and there is little need for irrigation. The wettest months in the study region are May and June, followed by a period of high evaporation rates in midsummer, which rapidly reduces the stored water supply.

Winter wheat requires irrigation through April to mid-May in order to achieve high yields (Figure 5-4). If significant precipitation has occurred during May, additional irrigation at this time will not increase yields; it may actually decrease the yields where the ground

Figure 5-2. Levee designed to direct surface runoff into a playa basin (top of photo) for augmenting the irrigation water supply (Nelson and Associates, Inc. 1981).

Figure 5-3. Playa basin (upper left) used for storage of water to irrigate cotton fields (foreground) in the Texas High Plains (Nelson and Associates, Inc.).

becomes wet during harvest in June (Hauser 1968). Therefore, the use of playa water for irrigating winter wheat is negligible. Cotton requires irrigation from mid-July to mid-August (Figure 5-5), and grain sorghum should be irrigated during August (Figure 5-6) when evaporation rates have increased sharply. During the 10 to 14 days it takes after a rain or irrigation for the soil to dry sufficiently to accommodate 4 in (10 cm) of irrigation water, a 100-ac (40-ha) playa would evaporate 25 ac-ft (30,800 m^3) of water (Hauser 1968). The practical use of playa water for these crops, then, would depend to a large extent on playa modifications to concentrate water and reduce evaporation. Efficient playa use would require both warm- and cool-season crops that can be irrigated (Guthery et al. 1981).

Many playas not only serve as drainage basins for collecting natural runoff, but also for recovering tailwater from irrigated fields. Large playas are much more likely to receive tailwater than small playas (Guthery et al. 1981). Recycling tailwater is relatively economical as the high pumping costs for groundwater extraction have already been paid, but is not cost-effective because it wastes limited groundwater supplies. There is a significant correlation between the presence of tailwater and playa modifications. Guthery et al. (1981) found that 91% of the playas receiving tailwater were altered (Figures 5-7 and 5-8).

There are, of course, other methods to reduce evaporative losses of irrigation water that are not concerned with the playa basin itself. One approach is the conversion of inefficient water application methods, particularly furrow irrigation, to more efficient low-pressure aerial sprinkling. Also, crop residues may be left in the fields to reduce evaporation, and techniques for terracing and minimum tillage may be used.

Recharge of Aquifer Supplies. Efforts have been made to recharge the Ogallala Aquifer with playa lake water for long-term storage and eventual reuse. When deep tailwater reservoirs were first excavated, it was discovered that, without a continuous clay lining within the playa basin, the reservoirs lost large amounts of water from seepage. It was determined that Pleistocene sediments underlying the playas were much more permeable than the playa soils, and experiments were conducted by digging deep pits to promote the seepage of playa water into the aquifer (Dvoracek 1981; Templer 1978; Aronovici, Schneider and Jones 1970). These recharge pits were generally unsuccessful, as suspended clay particles eventually sealed the bottom. The recharge of playa lake water into the aquifer can also be accomplished by injecting the water through wells. Wells can be used in any aquifer formation (Hauser and Lotspeich 1968), while recharge pits and reservoirs are usable only where the underlying sediments are fairly permeable (Keys and Brown 1970).

There has been some concern that the Ogallala may become polluted by dissolved pesticides, bacteria and viruses, but early studies found the quality of playa lake water to be as good as, or superior to, that of the groundwater, at least with respect to pesticides (Lehman 1972; Wells, Huddleston and Rekers 1970). Recharge water needs treatment, however, for sediment-laden water can clog wells or, in time, plug the interstitial spaces in the aquifer.

5.2 CROP CULTIVATION AND GRAZING

For the farmer, a playa basin that is unmodified may represent a financial liability. Such a playa probably is not a reliable source of water and, if the farmer plants crops within the playa basin, there is the risk of flooding and crop failure. If the farmer does not plant, weeds and pests produced at a cropland playa must be controlled and taxes paid, expenditures that are not offset by income (Bell and Sechrist 1972). Even considering the risks involved, many farmers plant into the margins of the playa or cultivate the basin, which requires deep plowing to

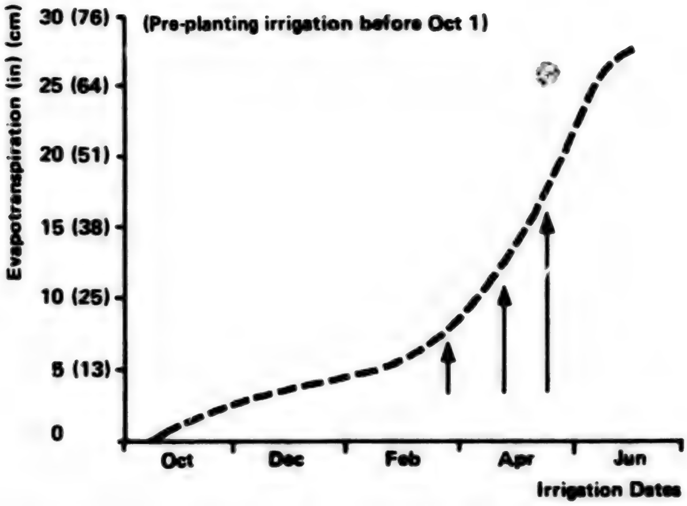

Figure 5-4. Cumulative evapotranspiration and recommended irrigation dates for winter wheat in Potter County, Texas (Hauser 1968).

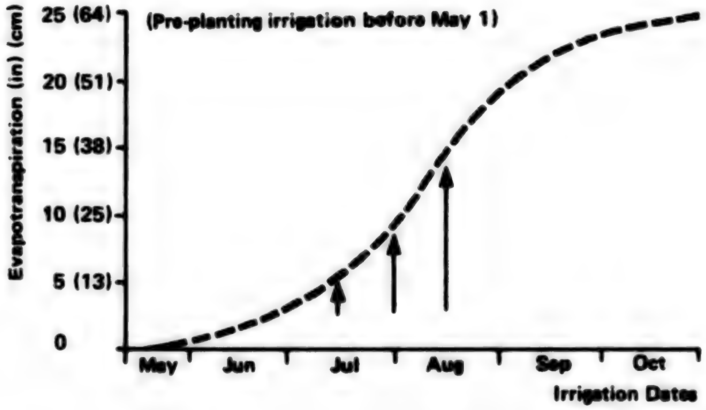

Figure 5-5. Cumulative evapotranspiration and recommended irrigation dates for cotton in the Texas High Plains (Hauser 1968).

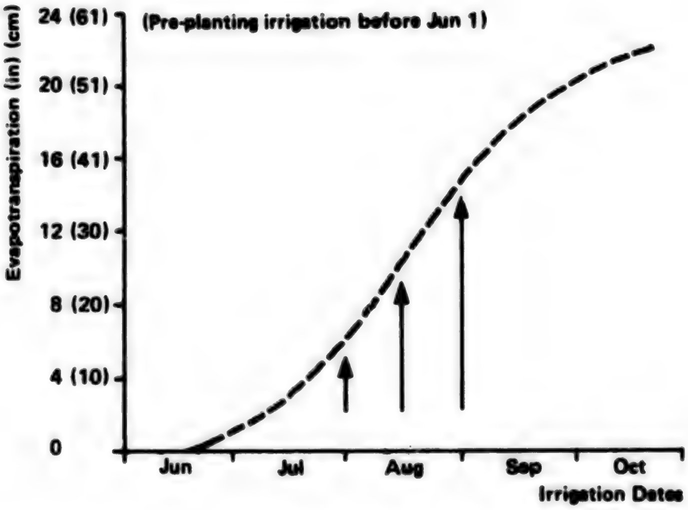

Figure 5-6. Cumulative evapotranspiration and recommended irrigation dates for grain sorghum planted in mid-June in Potter County, Texas (Hauser 1968).

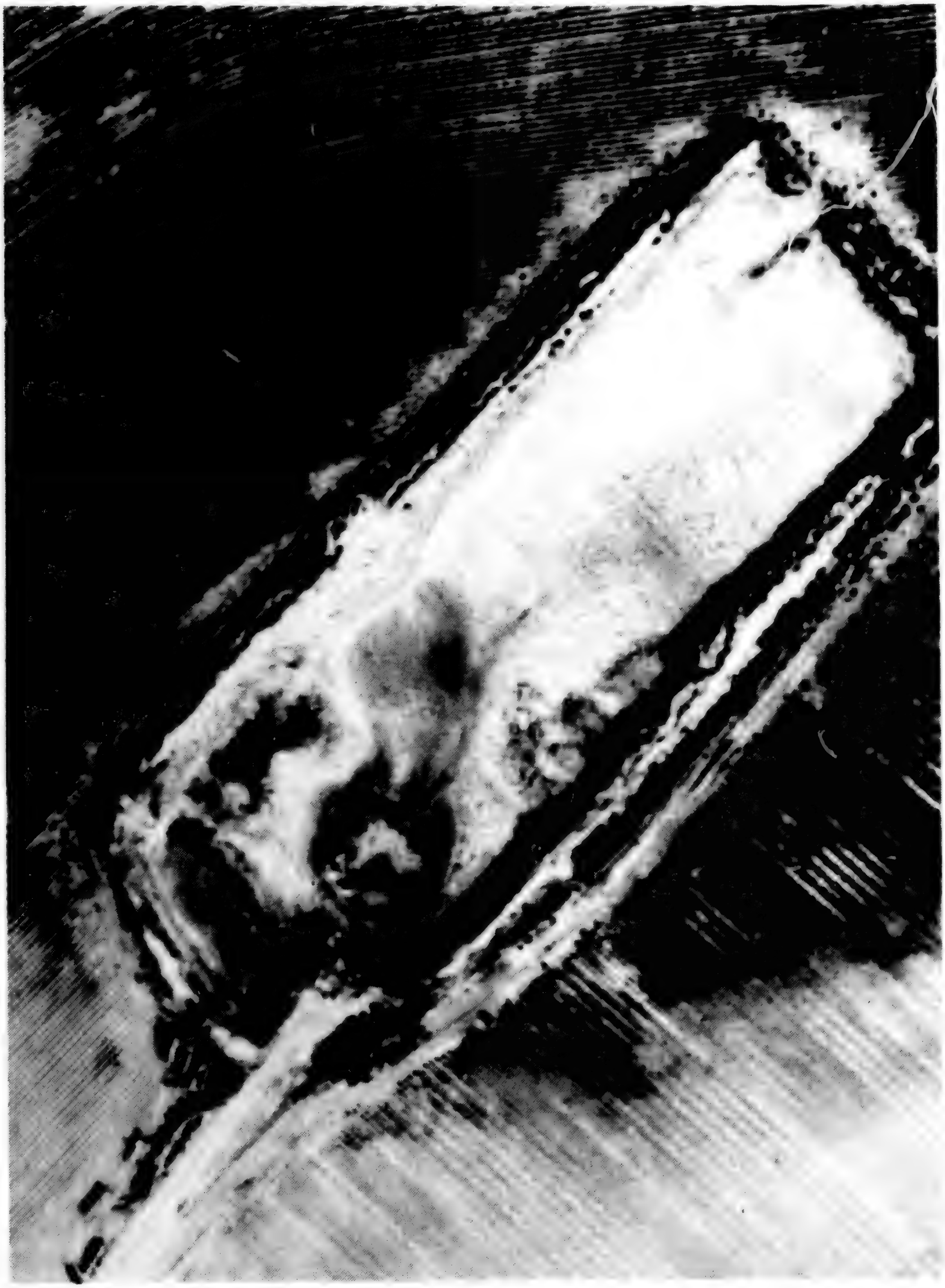

Figure 5-7. Playa basin radically modified by diking and excavation of 30,000 m^3 of soil to increase irrigation tailwater recovery (Texas Tech University, Department of Range and Wildlife Management 1981).

break through the "hardpan" clay lining (Simpson et al. 1981).

Guthery et al. (1981) found that unmodified playas having less than 30 ac (12 ha) of surface area were likely to have a greater proportion of cultivated area within the basin than playas over 30 ac. Small playas can be farmed successfully more often than not. Small basins having small watersheds are less inclined to receive irrigation tailwater and to be flooded seasonally than large playas. The large playas, even when modified, often have steeper slopes and are more suited as pasture land than for cultivation. The modifications themselves, which create spoil banks, pits, and trenches, will decrease the amount of arable land at small basins. At large playas, such modifications can result in a net increase of tillable land by reducing the flooded surface area.

Wheat is grown successfully in playa basins more often than any other crop (Mooreman 1963). Guthery (1980) determined that even if the major surrounding crop is cotton, the Randall soil zone may be planted in winter wheat. This practice is quite common in areas with sandy soils. The cultivation of a crop in the main playa basin different from the crop in surrounding fields is not unusual (Figure 5-9).

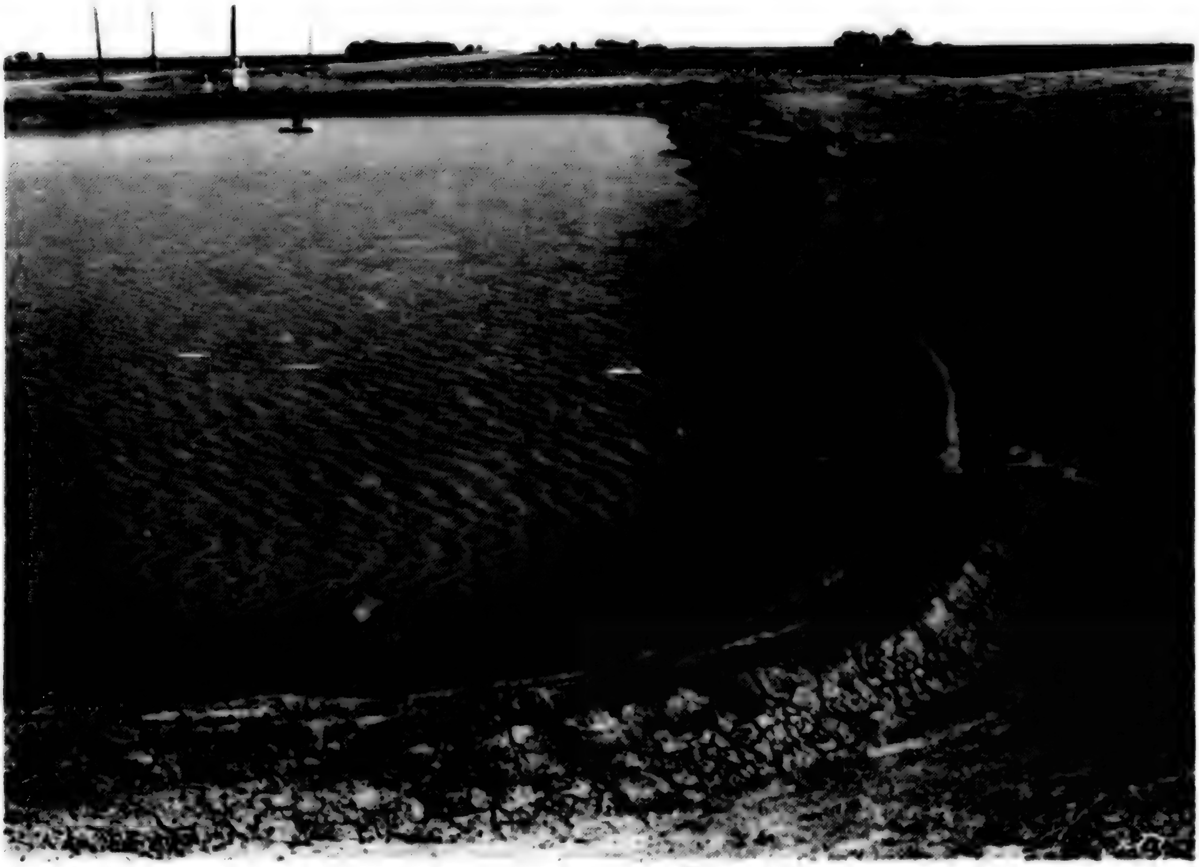

Figure 5-8. Example of a playa basin modified by excavation to increase storage and recycling of irrigation tailwater (note floating pump in background) (Nelson and Associates, Inc. 1981).

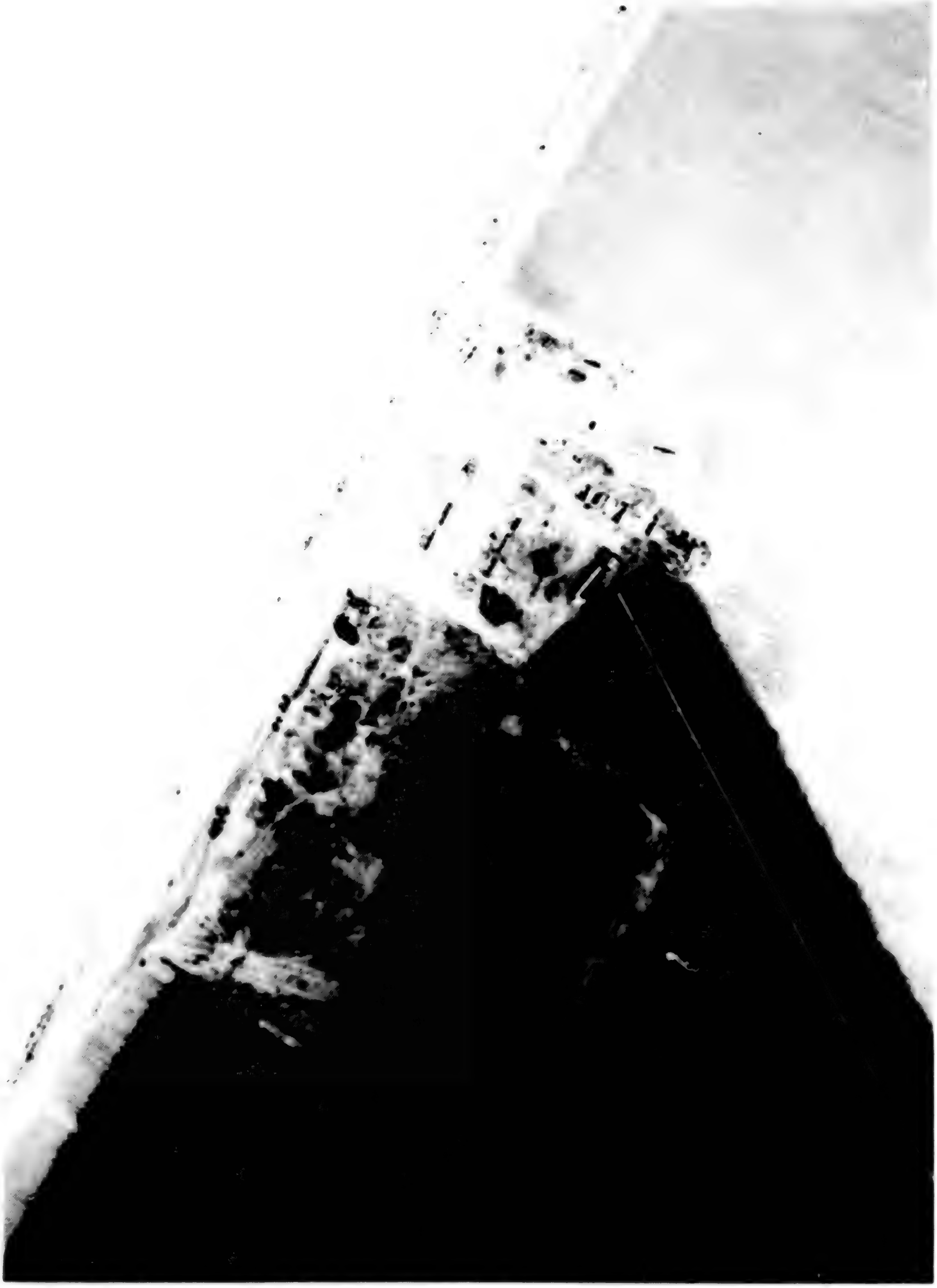

Figure 5-9. Aerial view of a playa basin incorporated into a center-pivot irrigation sprinkling system; most of the basin is planted in switchgrass with cotton surrounding it (Texas Tech University, Department of Range and Wildlife Management 1981).

MICRO[illegible] BEST
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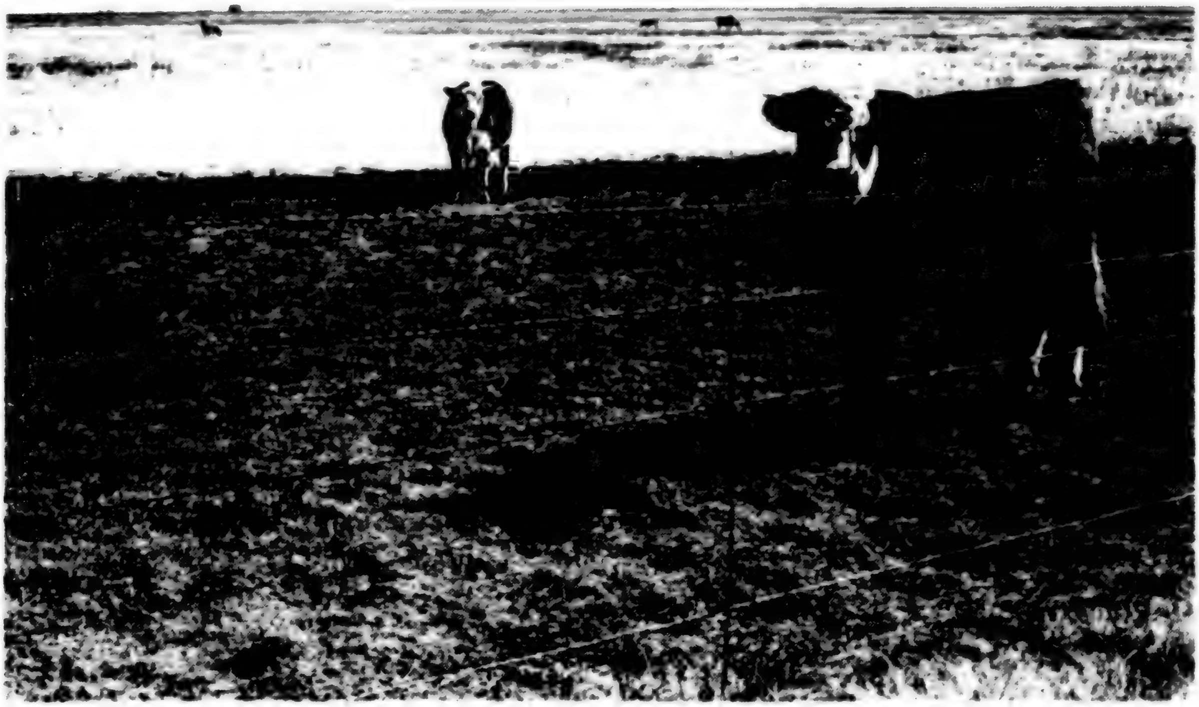

Figure 5-10. Typical Texas High Plains playa wetland fenced and grazed by both cattle and horses (background) (Nelson and Associates, Inc. 1981).

Grazing of Livestock. The use of playa basins for grazing of livestock is widespread (Figure 5-10). Guthery et al. (1981) estimated that nearly one-half of playas in all size classes are used for grazing, but the proportion increases to two-thirds for playas over 10 ac (4 ha). Data presenting the mean for each zone of the study region (Table 5-2) are conservative because unfenced playas that might be grazed are excluded. It is a common practice to erect temporary electric fences after a corn or wheat harvest to allow grazing during the cool season between harvest and planting. Large numbers of cattle are intensively grazed in this manner (Simpson et al. 1981). Playas surrounded by rangeland are usually grazed year-round, limiting the growth of emergent vegetation.

Hereford steers grazing on native vegetation in a playa basin gained up to 3 lb (1.4 kg) a day for 60 days, indicating that natural playa vegetation is extremely nutritious forage (Hauser 1968). The species commonly used as forage are short grasses such as buffalo grass, which grows luxuriantly on the periphery of playa basins (Guthery 1980); others are forbs such as kochia. Guthery, in a personal communication, reports that kochia is a good protein source (up to 18%).

5.3 HUNTING AND FISHING

Hunting, particularly for pheasant, ducks and geese, is the main recreational use of playas. The suitability of a playa for hunting depends on several factors, including size, amount of open water, and vegetative cover (Figure 5-11). The extent of open water and the type of cover determine which species are most inclined to inhabit the playa basin.

Table 5-2. Percentage of playa basins fenced for livestock grazing, by zones of the study region (Guthery et al. 1981).

	Playas Fenced No.	Playas Fenced %
North Cropland Zone	141	27
North Rangeland Zone	258	68
South Cropland Zone	311	47
Irrigated Cropland Zone	285	54
South Rangeland Zone	150	48
Study Region	1,145	48

Large playas with abundant, shallow open water are more likely to be used by cranes and geese. Seasonal grazing around these playas encourages the growth of grass sprouts and cool-season forbs on which these birds feed (Guthery, personal communication). These open lakes also are used more by pintails and wigeons (Moore 1980). Smaller playas with dense stands of emergent vegetation, such as smartweed and cattails, are used by mallards and green-winged teal (Moore 1980; Bennett and Bolen 1978). Playas with thickets of trees attract mourning doves (Simpson and Bolen 1981). The nearby availability of cultivated grains—corn, grain sorghum, and wheat—increases the value of a playa as a hunting site, as game species feed on these crops.

Hunting of ducks and other waterfowl has been rather light in the Southern Great Plains as compared to other regions in the Central Flyway (Funk et al. 1971). In 1979, 138,000 or one-third of the duck stamps were sold in Texas as compared to 413,000 for the entire Central Flyway (Bolen 1980). Texas is one of four or five states where sandhill cranes can be hunted legally under a special permit.

Pheasant is another game bird hunted effectively at playas. Guthery (1981b) observed that, by the time of the fall hunting season, most crop residues have either been grazed or plowed under, and cover along roadsides and ditches has been mowed, so little pheasant cover remains in cropland areas from December to June. Therefore, pheasants congregate around playa basins during this period. Farmers have reported harvesting as many as 25 to 40 cocks from playa basins 8-16 ha in size. Guthery (1981a) confirmed this estimate by flushing 150 hens and 36 cocks from one 12-ha basin during February 1979. At this density—approximately 15.5/ha—hunting success for this popular game bird is almost assured.

Mammals such as raccoons and cottontails are significant game species in playa basins. The desert cottontail is most abundant around shortgrass rangeland playas, while the eastern cottontail is most prevalent around cropland playas. Both species can obtain water from their food sources and, like pheasants, are attracted to playa basins because of the cover they provide, not because of water availability (Simpson and Bolen 1981). Winter cottontail population densities as high as 9.25/ha around playa basins assure hunting success. Raccoons are attracted to playa basins because they provide major sources of food and cover. The availability of corn and wheat can also be a factor in their survival; other grains apparently are not consumed. Raccoons generally are trapped rather than hunted.

Sport Fishing and Other Uses. There are few resident species of sport fishes in playa lakes because of the intermittent water supply. Moore (1980) reported the existence of a sport fishery in one large playa normally having 37 ac (15 ha) of water surface (up to 50 ac or 20 ha after heavy rains) and a depth greater than 6.5 ft (2 m). Some modified playas that contain water year-round are also capable of maintaining a sport fishery. Ward and Huddleston (1972) reported that two such playas, one with a central pit 17 ft (5.2 m) deep and the other with a peripheral pit 12 ft (3.7 m) deep (plus a dam and diversion terraces), supported largemouth bass, bluegills, and catfish. The growth rates for these fishes are quite low because of low plankton production; the pits are steep-sided with no littoral zone and result in low aquatic productivity.

Guthery (personal communication) has found that it is a common practice for landowners in the Southern Great Plains to purchase catfish from private producers to stock the playas, but there are no state management or stocking programs to create sport fisheries in playa lakes. Another possible fishery use of playas is to cultivate minnows as bait. At least one permanent playa lake in the southern part of the Texas Panhandle is used for this purpose (Guthery et al. 1981).

Two additional recreational uses of playas may be mentioned. The capacity of playa basins to concentrate large numbers and diverse species of wildlife make these sites an excellent resource for the nature lover, birder,

Figure 5-11. Good hunting site at a playa basin often combines open water with shoreline and emergent vegetation providing dense cover (Nelson and Associates, Inc. 1981).

or wildlife photographer. Moore (1980) documented 92 species of birds at 16 playas in Castro County, Texas, including five species of hawks, the white pelican, snow goose, osprey, snowy egret, great blue heron, and burrowing owls, as well as the many other species of waterfowl, shorebirds and gulls that are expected in marshy environments. Several playa basins are used as municipal parks in the City of Lubbock, Texas. This use is not widespread; only Curry, Dawson, Lubbock, and Potter Counties, or 0.1% of the 2,410 playas in Guthery's playa assessment study, have formalized recreational use of playa basins.

5.4 WASTE TREATMENT AND DISPOSAL

Playas are sometimes used as municipal sewage disposal sites. Two of the 588 playas over 10 ac (4 ha) that are covered in the playa assessment study by Guthery et al. (1981) were used for this purpose. The City of Lubbock, Texas, has been pumping treated effluent from its wastewater reclamation plant into modified playas on the Gray farm since 1939. The water is reused to irrigate approximately 3,000 ac (1,215 ha) of cotton, soybeans, wheat, corn, alfalfa, and sunflowers. Large numbers of waterfowl can be seen at the Gray farm playas, probably because of the large expanse of permanent water.

Inflows of sewage effluent exceeding playa storage capacity on the Gray farm have resulted in application to crops at rates higher than optimum for plant growth. These modified playas have had leakage problems compounded by percolation from overwatered fields, causing seepage into the aquifer. The groundwater elevation beneath the Gray farm has risen 80 ft (24 m) to within 10 ft (3 m) of the surface and contains three times the nitrate concentration considered safe (10 ppm) for domestic water supply. Newly modified playa basins receiving this sewage effluent will be sealed with up to 2 ft (60 cm) of clay liner to avoid seepage. As long as playas used for municipal sewage disposal can accommodate the amount of effluent being supplied, this use is beneficial, especially where an irrigation water supply is supplemented. However, major problems result from operating over capacity (Lubbock Christian College 1979).

Disposal of Feedlot Waste. The cattle industry in the Southern Great Plains is very extensive; in the Texas Panhandle in 1970 there were one million cattle, mostly concentrated in feedlots with capacities between 5,000 and 90,000 animals (Lehman 1972). Such high concentrations have made the containment and disposal of wastes an important problem which often has been solved by impounding feedlot wastes in playa basins or excavated retention basins (Figure 5-12).

Lehman (1972) compared seepage rates of pumped groundwater and feedlot runoff in playa clay soils and the underlying Pleistocene material that is exposed when excavating a retention basin. The results indicate that Pleistocene sediments allow considerable seepage of feedlot runoff, while playa clay substrates create a fairly impermeable barrier (Table 5-3). There is a build-up of nitrate and ammonia at a 1-ft (30-cm) depth below the playa surface, but at 2 ft (60 cm) there are only traces of these runoff constituents (Table 5-4). Chloride moved deeper into the playa sediments, but below 4 ft (120 cm) the concentrations were negligible. Under the anaerobic conditions present in playa basins used for impoundment of feedlot runoff, several processes occur which reduce the nitrates and nitrites available for seepage. Anaerobic conditions cause reduction of nitrates to nitrites, ammonium is fixed by nitrogen-fixing bacteria, and considerable amounts of ammonium are volatilized into the atmosphere.

These results make it clear that excavated basins are a poor solution for impoundment of feedlot runoff, and that playa basins are safe since little seepage occurs. However, subsequent use of untreated feedlot runoff for irrigation may cause salinity problems in cropland soils. Feedlot

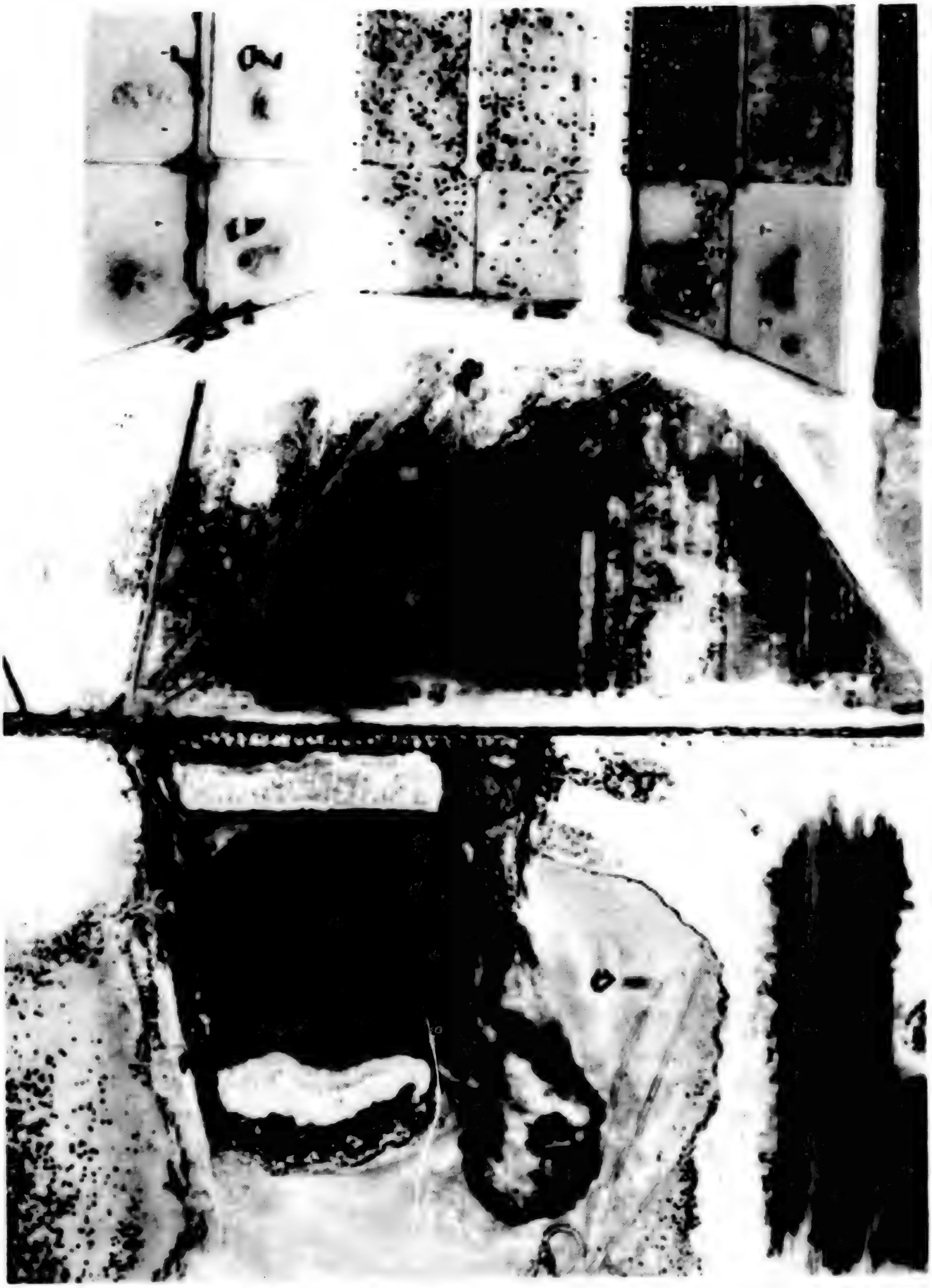

Figure 5-12. Aerial infrared photo of cattle feedlots adjacent to a playa basin ditched and excavated to impound feedlot runoff (Texas Tech University, Department of Range and Wildlife Management 1981).

Table 5-3. Chemical analysis of effluent from undisturbed cores of playa clay and Pleistocene material in Randall County, Texas (Lehman 1972).

Core Material	Water Used	Chemical Oxygen Demand (COD) (ppm)	Chloride (ppm)
Playa Clay	Ogallala	40	15
	Feedyard	40	25
		50[1]	50[1]
Pleistocene	Ogallala	40	40
	Feedyard	800	800
		40[1]	650[1]

[1] After 70 to 100 days of continuous exposure to feedyard runoff.

runoff applied to croplands may also percolate deeper into the soil horizons than when confined in a playa basin, with a potential for pollution of the aquifer.

Petroleum Production Waste. Some playas, particularly the salt playas in the southern part of the study region, are used for disposal of oil field brine. When the oil wells in the Texas High Plains were first drilled about 50 years ago, the oil recovered was quite pure; now it is mixed with saltwater and must be separated mechanically. Generally, the brine remaining after separation is pumped back underground to force more oil out of the rock formations in a process known as secondary recovery (Randall 1978). In some instances, though, it is too costly to use the large compressors required to inject the brine underground, and the alternative is aboveground disposal.

Between 1969 and 1979, about 5,500 permits to dump brine into playa basins were granted by the Texas Railroad Commission, which has jurisdiction over oil production and waste disposal (Vogler 1979). Several playas in Texas known to be involved include Cedar Lake, Gaines County (5,000 ac or 2,000 ha); Mound Lake, Terry and Lynn Counties (1,500 ac or 600 ha); Lake Whalen, Andrews County (330 ac or 135 ha); and Soda Lake, Crane County (less than 100 ac or 40 ha). Other playas receiving oil field brine are in Lea County, New Mexico, and in several areas of Oklahoma (Brewster 1979). Pipelines leading to Lake Whalen discharge up to 5,000 gal (19 m^3) of brine a day; most of the other lakes receive brine from tanker trucks (Randall 1978).

There are several chemical effects of brine disposal, including the build-up of dissolved solids and chlorides as well as hydrocarbons, acids, rust inhibitors, and heavy metals (Erskine 1981). At Whalen Lake, 176 ppm of hydrocarbons were found in the water, which is 156 ppm above the 20-ppm standard (Vogler 1979). In 1963, before dumping, Mound Lake had 141,500 ppm of chlorides (seven times the salt content of seawater) and 360,000 ppm of dissolved solids (11 times the dissolved solids content of seawater). After 16 years of brine disposal, the lake had accumulated between 160,000 and 203,000 ppm of chlorides and between 330,000 and 360,000 ppm of dissolved solids (Brewster 1979).

The pollution of surface waters can contaminate groundwater through seepage into the aquifer. A 1973 Lea County, New Mexico,

Table 5-4. Seepage of nitrogen and chloride below a playa in Randall County, Texas, used as a feedyard (Lehman 1972).

Depth (ft)	(cm)	Low-Elevation Sites (ppm) NO_3^--N	NH_4^--N	Cl^-	High Elevation Sites (ppm) NO_3^--N	NH_4^--N	Cl^-	Non-Feedyard Playa (ppm) NO_3^--N	Cl^-
1.0	(30)	200	16	300	1.2	3	90	8	140
2.0	(61)	6	6	250	0.3	3	60	3	110
3.0	(91)	3	5	140	0.1	3	50	3	50
4.0	(122)	1	4	100	0.1	1	20	2	30
5.0	(152)	2	3	40	0.3	1	30	-	-
6.0	(183)	2	3	50	0.1	1	20	-	-

Note: All values in the table are average for the sites sampled.

land use planning study reported that a 110-ac (45-ha) area of the Ogallala Aquifer is contaminated with 4,000 ppm of salt, which translated to 100 x 10^6 gal (380,000 m^3) of polluted groundwater (Vogler 1979).

5.5 WATER SUPPLY AND DISEASE CONTROL MODIFICATIONS

Playa modifications to increase water storage must decrease the surface area-to-depth ratio in order to reduce evaporation. There are several methods for accomplishing this, including excavation of pits and ditches; constructing dikes, diversion terraces, and levees; and reshaping the entire playa basin. Guthery et al. (1981) identified 50 types of playa alterations involving different placement of basic structural elements.

At a typical unmodified playa basin with a maximum depth of 6.0 ft (1.8 m), a water volume of 24.5 ac-ft (30,225 m^3) would fill it halfway to its outermost rim, exposing 14.7 ac (6.0 ha) of water surface to the evaporative forces of sun and wind (Figure 5-13). A playa basin with a simple pit excavated at the center, when filled to the same elevation, would hold slightly more volume (29.2 ac-ft or 36,025 m^3) but would expose only 7.0 ac (2.8 ha) of water surface (Figure 5-14).

Pits, also called sumps, may be constructed simply, without a surrounding berm and spillway, so that surface runoff can enter the excavation from all sides. This type of pit is most often located in the center of the playa (Figure 5-15). Another type of pit, usually excavated at the periphery of the playa basin, has a dike around three sides and receives runoff through a pipe spillway under the dike (Figure 5-16). Peripheral pits may also connect to a system of *internal* ditches that drain the playa basin more effectively (Figure 5-17). Ditching may also be used *externally* to channel storm runoff into the playa basin (Figure 5-18), or into an excavated storage pit with a circular diversion terrace directing runoff to the inlet channel (Figure 5-19).

Modifications Designed for Aquifer Recharge. Artificial recharge of the Ogallala formation through pits or trenches entails a large amount of "earth work" to excavate playa clays and to expose the more permeable Pleistocene strata through which seepage to the aquifer can occur. Suspended clay particles eroding from the sides of the pit, however, often clog the Pleistocene sediments, eventually sealing the recharge basins.

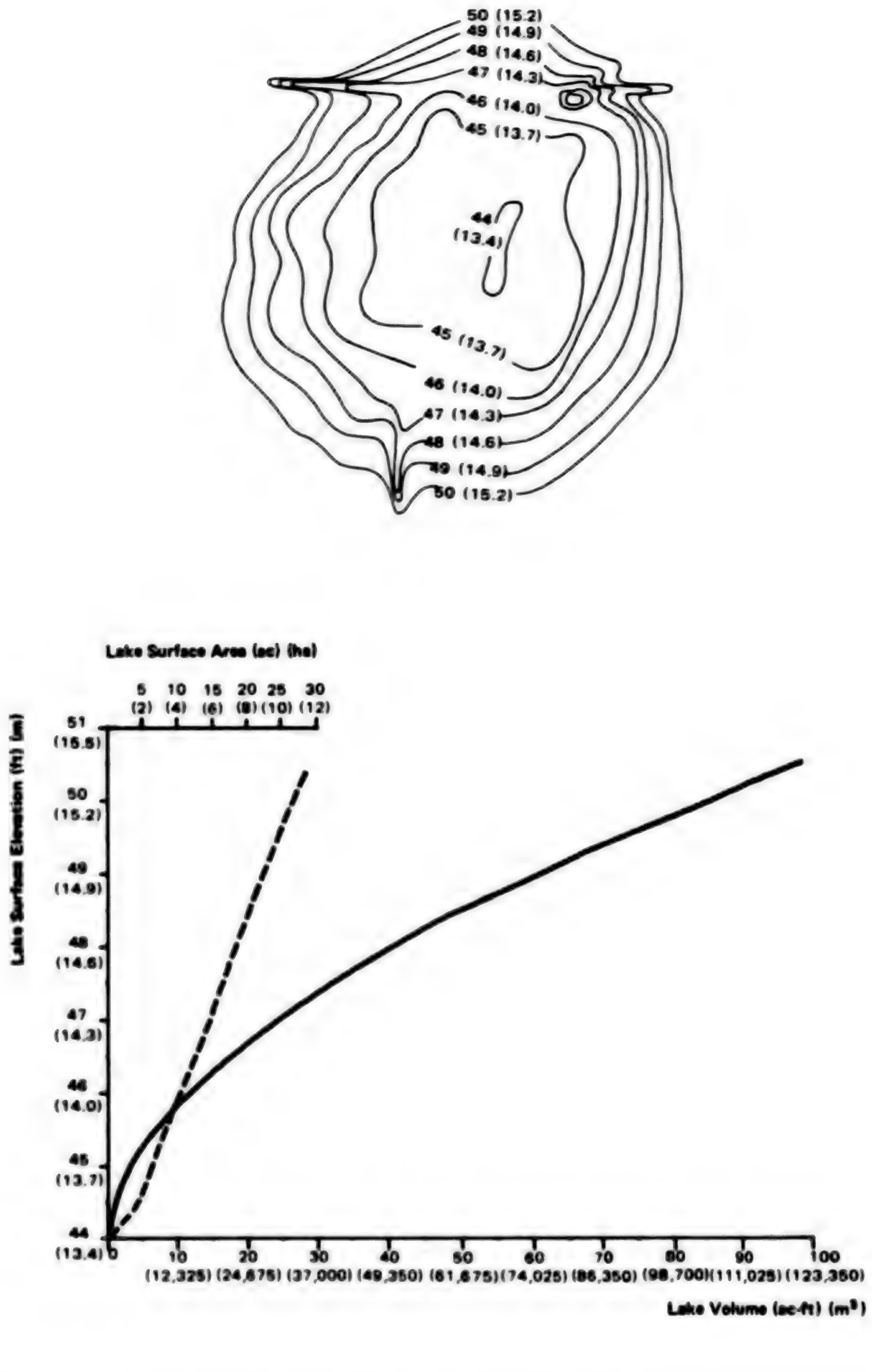

Figure 5-13. Land surface configuration and area-volume curves for water elevations in a typical unmodified playa basin on the Texas High Plains (Ward and Huddleston 1972).

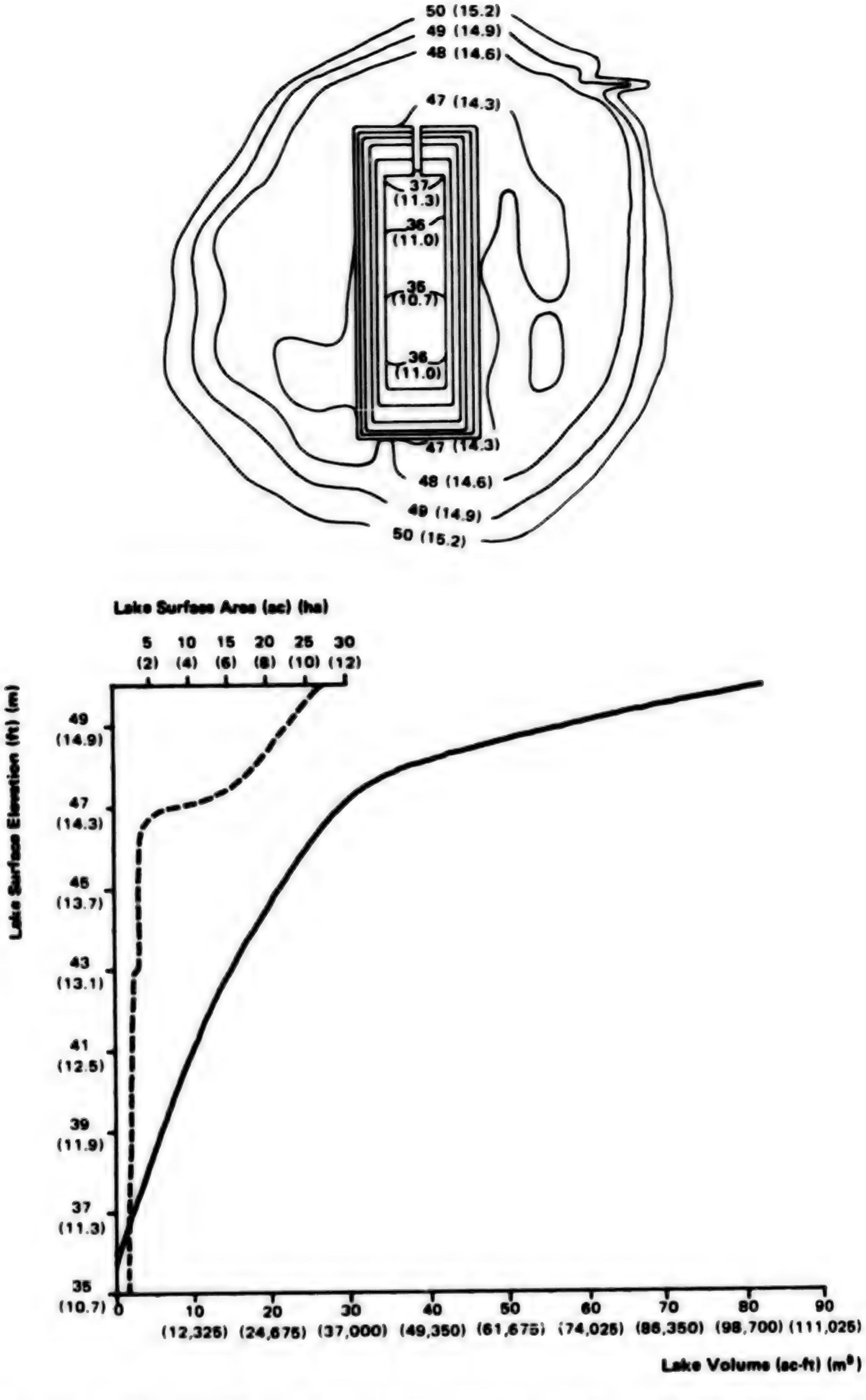

Figure 5-14. Land surface configuration and area-volume curves for water elevations in a typical playa basin on the Texas High Plains after being modified by excavation of a central pit (Ward and Huddleston 1972).

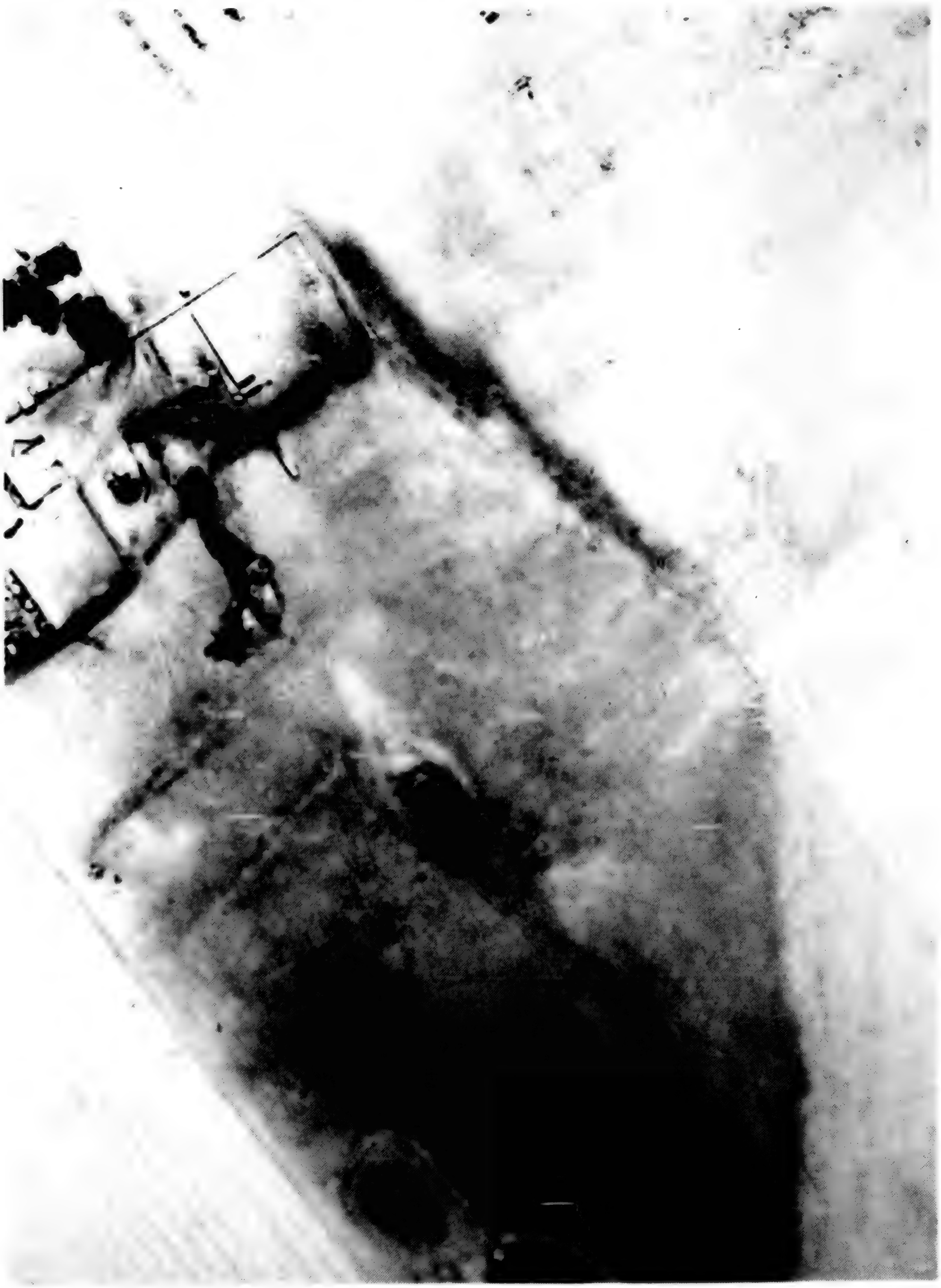

Figure 5-15. Example of a simple central pit excavation designed to intercept playa watershed runoff in all directions (Texas Tech University, Department of Range and Wildlife Management (1981).

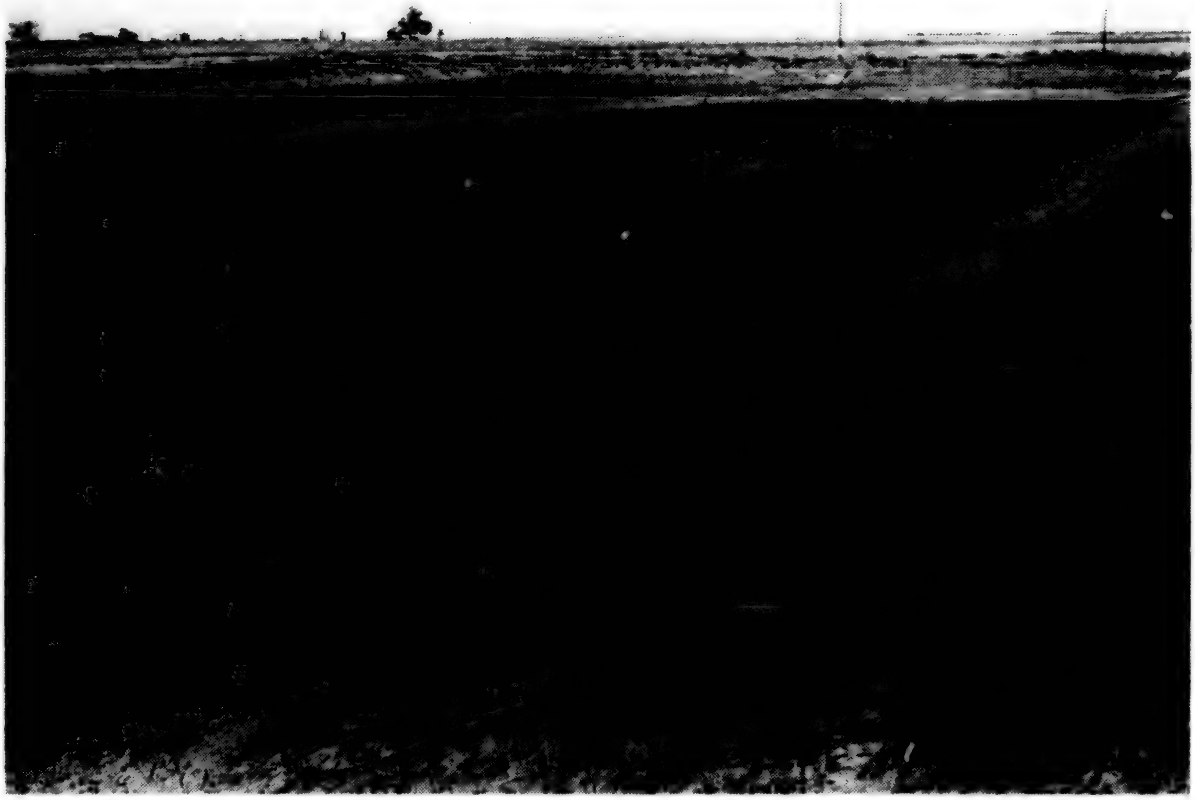

Figure 5-16. Example of a peripheral pit excavation with surrounding dikes, designed to intercept playa surface runoff at one side through a pipe spillway (Nelson and Associates, Inc. 1981).

To assure continued use of these recharge pits, they were often dried and scraped free of deposited clay particles before refilling (Jones, Goss and Schneider 1974). Some other management techniques that were investigated to prevent sealing the basin and reducing suspended solids included using flocculents, corrugating the basin surface, providing increased flooding depths, and using a removable mat as a filter.

The injection of playa water into the aquifer can be accomplished with single-purpose recharge wells or dual-purpose irrigation wells. If water is not clarified before being pumped into the aquifer, however, the suspended sediments clog the pumps and the pores of the aquifer. Treatment of playa water before recharge entails the construction of a filtering or water clarification system with settling basins in which flocculents are used. A drainage and filtering recharge system in which playa water seeps through the lake bed into a series of parallel pipes buried about 3-4 ft (0.9-1.2 m) below the playa lake bed has been used in Texas (Figure 5-20). The system of pipes is connected directly to a recharge well.

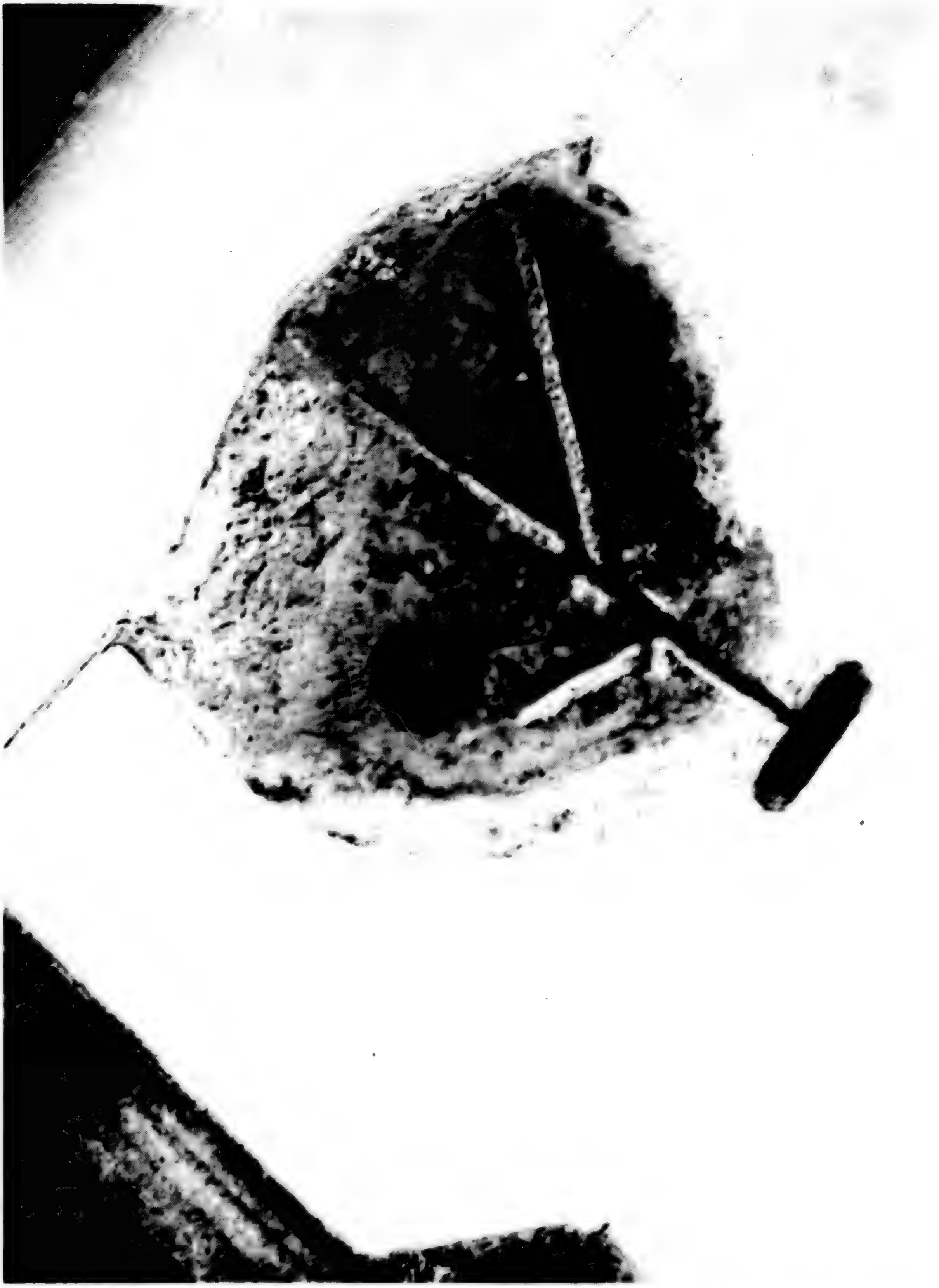

Figure 5-17. System of drainage ditches designed to efficiently channel playa surface runoff into a peripheral pit for storage and use in irrigation of surrounding croplands (Texas Tech University, Department of Range and Wildlife Management 1981).

Modifications for Disease Control. Continued outbreaks of encephalitis in the Southern Great Plains are linked directly to the presence of mosquitoes that breed in playas (Grubb, Parks and Sciple 1968). The direct relationship between vegetative cover and mosquito production has been documented (Figure 5-21). As the proportion of playa surface area covered by vegetation increases up to about two-thirds, so does the density of mosquito larvae. Also depicted is the inverse relationship between water depth and numbers of mosquito larvae; as water depth increases up to about 2 ft (0.6 m), the density of larvae decreases. Playa modifications to reduce disease associated with mosquito production are therefore aimed at reducing the extent of vegetation or increasing the water depth.

Direct removal of vegetation by mowing and burning or inhibiting its growth by disking are the simpler measures, but they can be carried out only when the playas are dry. The effects of these practices are temporary, as repeated inundation will spur the growth of rooted aquatic plants. Disking may actually increase the growth of weeds by creating disturbed habitat where these species thrive. Alterations to increase water depth may involve digging pits and ditches and constructing berms, dikes, or levees. A slope ratio of 3:1 or steeper is necessary to inhibit the growth of rooted aquatics on the sides of pits or levees (Ward and Huddleston 1972). A mosquito control measure used in conjunction with increasing the water depth is stocking the top minnow *Gambusia*, which feeds on mosquito larvae. The survival of this fish depends on a continuous supply of water which can be a direct result of increasing the playa depth.

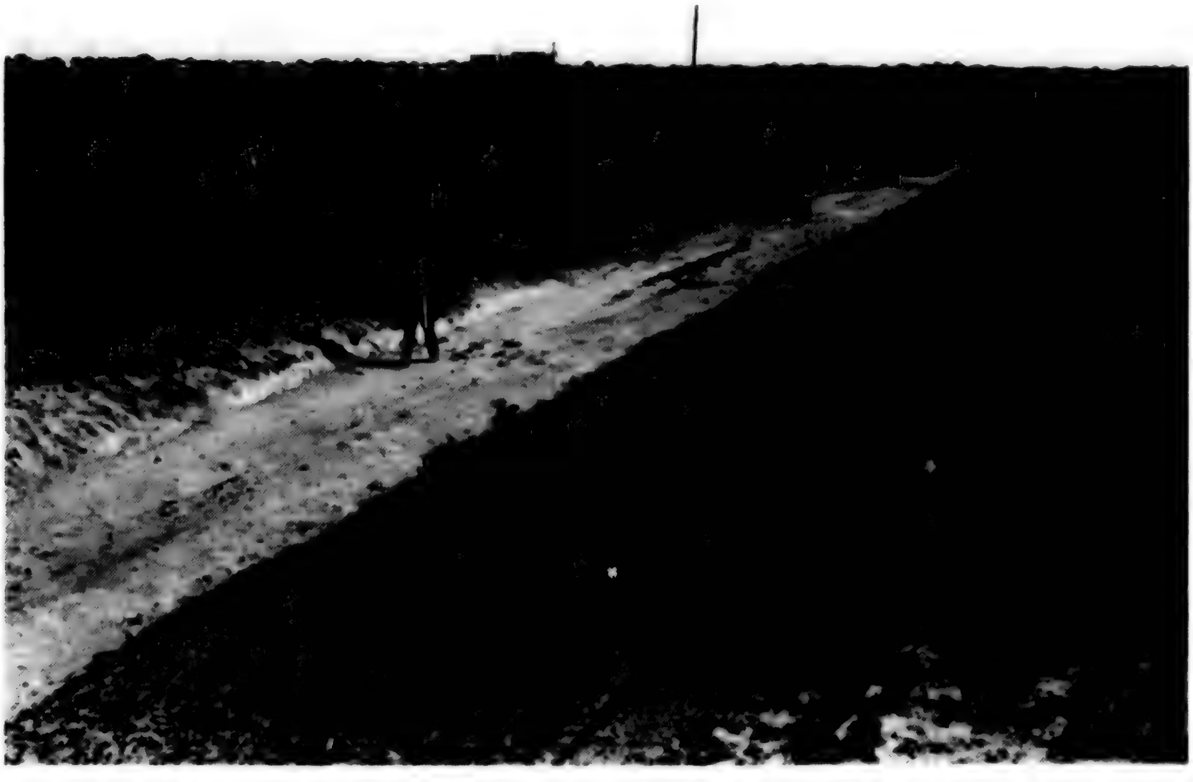

Figure 5-18: Drainage ditch built to channel storm runoff into a playa basin (upper right) for storage and irrigation use (Nelson and Associates, Inc. 1981).

Multipurpose Playa Modifications. With the exception of weed control measures to reduce mosquito production and the construction of aquifer recharge pits and wells, most other modifications made to increase playa water depth can be considered multipurpose. For instance, a combination of pit, dike and diversion terrace will reduce shallow water and emergent vegetation, and thereby decrease mosquito production, while also reducing evaporative water losses to provide extra water for irrigation and to maintain more permanent open water for wildlife and fish (Ward and Huddleston 1972).

Few playa modifications provide optimum benefits for all purposes. For example, a

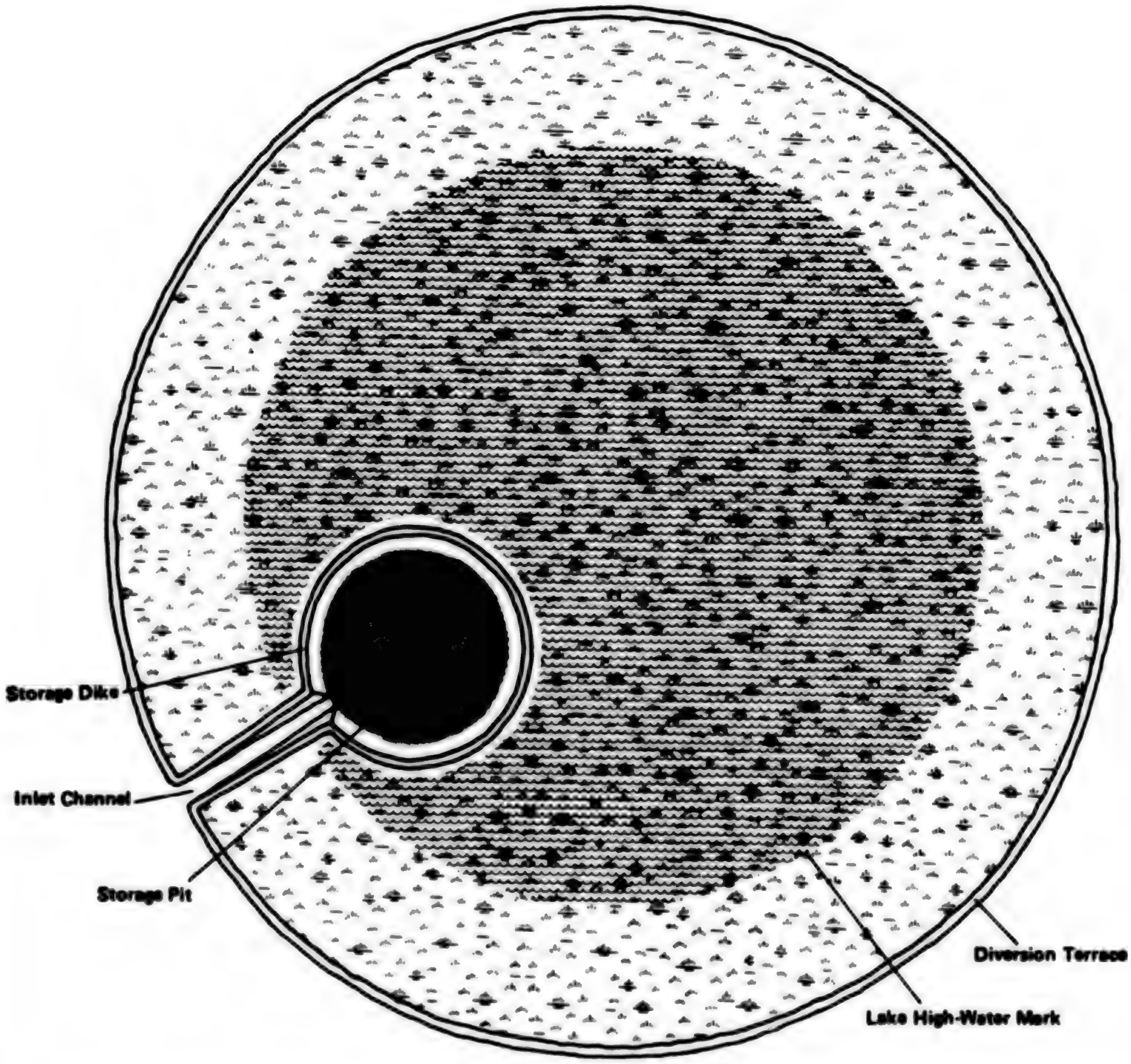

Figure 5-19. A scheme using a diversion terrace around the playa perimeter to channel surface runoff into a storage pit via an inlet channel (Grubb and Parks 1968).

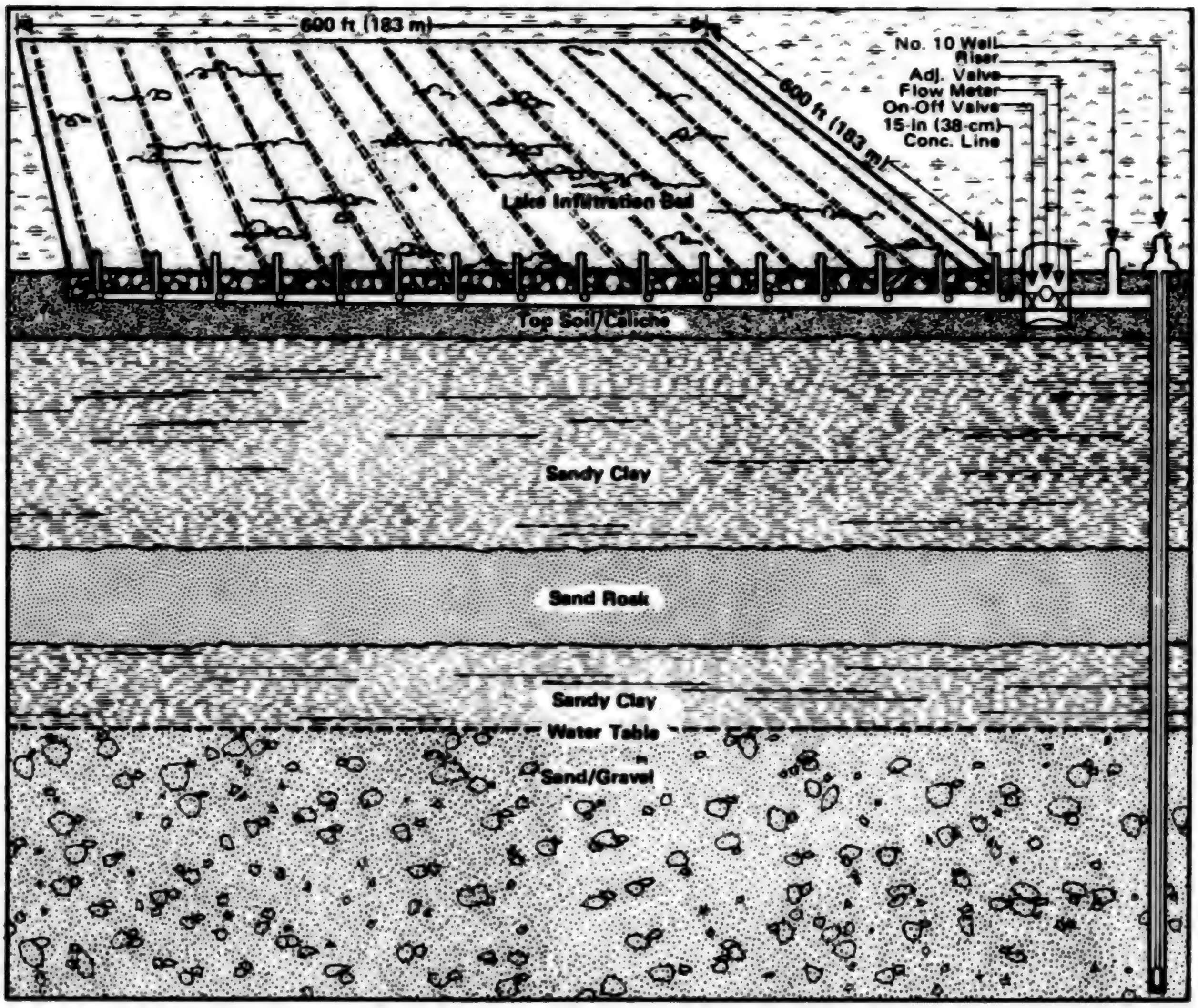

Figure 5-20. Scheme for a drainage and filtering system at Bushland, Texas, for recharging the Ogallala Aquifer using playa lake water (White 1959).

playa modified to provide a year-round water source for fish or wildlife cannot at the same time achieve an optimum level of irrigation because it cannot be pumped dry. Steep-sided pits and dikes reduce aquatic vegetation and mosquito production, but also eliminate the productive littoral zone of the playa lake and may reduce wildlife benefits (Ward and Huddleston 1972). It is necessary to determine and balance the benefits most desired before constructing a multipurpose playa modification.

5.6 STATUS OF PLAYA MODIFICATIONS

The current distribution of playa modifications in the study region has been estimated by counties (Figure 5-22). Generally, there are two areas in the region where more than 40% of the playas are modified; there is a cluster of four counties bridging the North and South Cropland and North Rangeland Zones, but the main concentration is a cluster of 11 counties in the south-central part of the region, primarily within the Irrigated Cropland Zone.

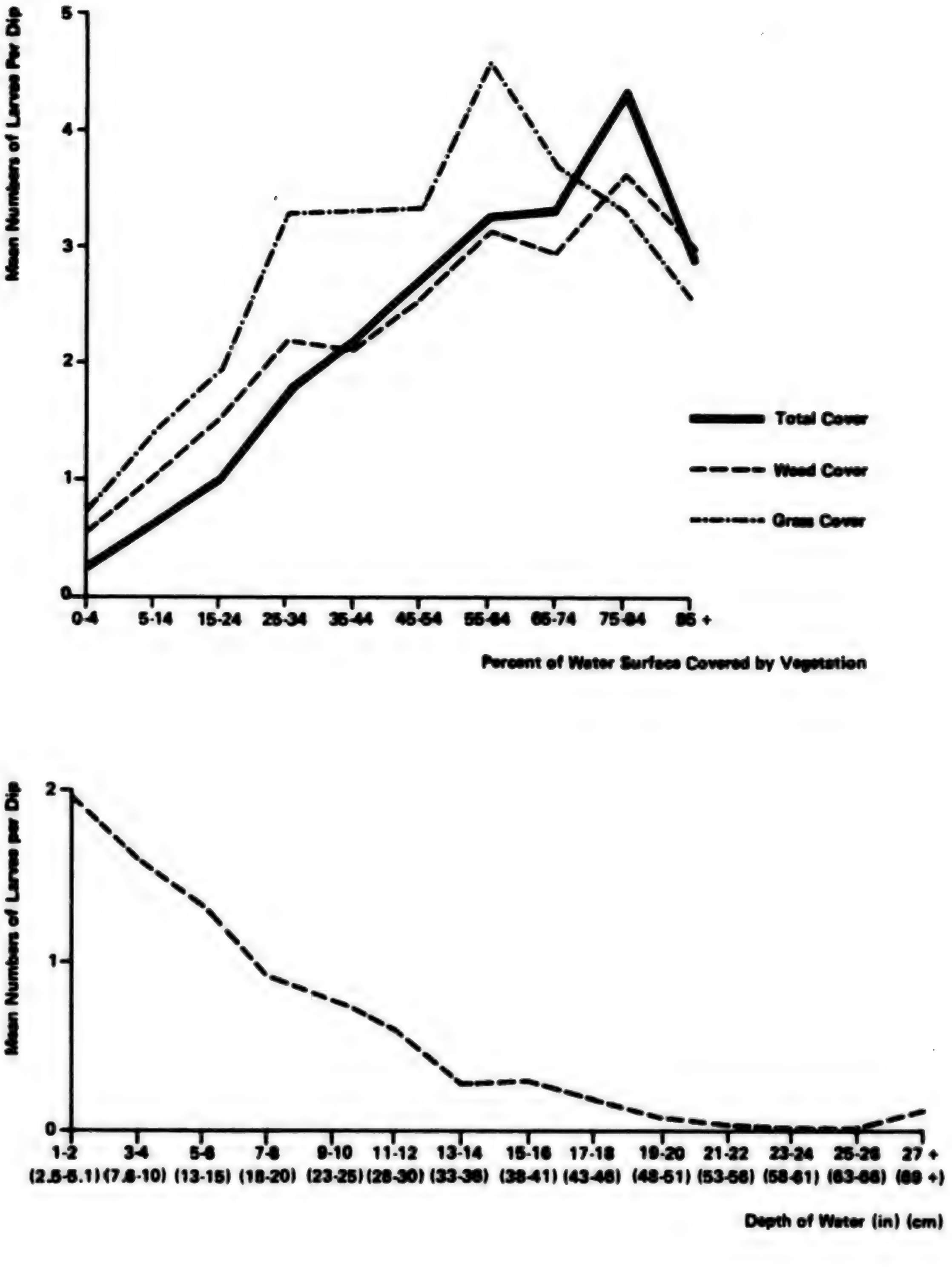

Figure 5-21. Relationships between mosquito production and the proportion of playa lake vegetative cover or depth of shallow water in Lubbock County, Texas (Ward and Huddleston 1972).

Table 5-5. Comparison of irrigated land with playas receiving tailwater (after Guthery et al. 1981).

% Irrigated	Playas Receiving Tailwater	
	No.	%
<10	14	2
10-20	15	3
21-30	69	14
>30	60	20

Most of the counties in the main cluster are in the "hardland," fine-textured soil region where playas tend to be larger and less numerous. Guthery et al. (1981) found that 70% of the playas over 10 ac (4 ha) in size were modified; this explains in part why there is a high proportion of modifications in this area. In the south-central Irrigated Cropland Zone, the playas receive considerable irrigation tailwater (Table 5-5), so the very dense concentration of modified playas in this zone (Table 5-6) apparently reflects the efforts to recover and reuse tailwater (Guthery et al. 1981). Castro, Floyd, Hale, Lamb, Parmer, and Swisher Counties in Texas have a high proportion of playas with pumps installed for use in irrigation (Figure 5-22).

The lack of extensive modifications in most counties of the North Cropland Zone, an area of smaller playas less susceptible to modification, may also have to do with the growing of wheat, which is a major crop here. Growing wheat requires the most water during April, May and early June, when most of the precipitation occurs. Using playas for augmenting irigation water later in the growing season probably would not be necessary for this crop (Hauser 1968). The lack of extensive modifications in the South Rangeland Zone may attribute to the small size of playas in this district, plus the fact that grazing would not be greatly benefited. Guthery et al. (1981) found that 95% of the playas under 10 ac (4 ha) were unmodified.

Table 5-6. Comparison of irrigated land with playas having modifications (after Guthery et al. 1981).

% Irrigated	Playas Modified	
	No.	%
<10	160	25
10-20	185	34
21-30	211	41
>30	182	60

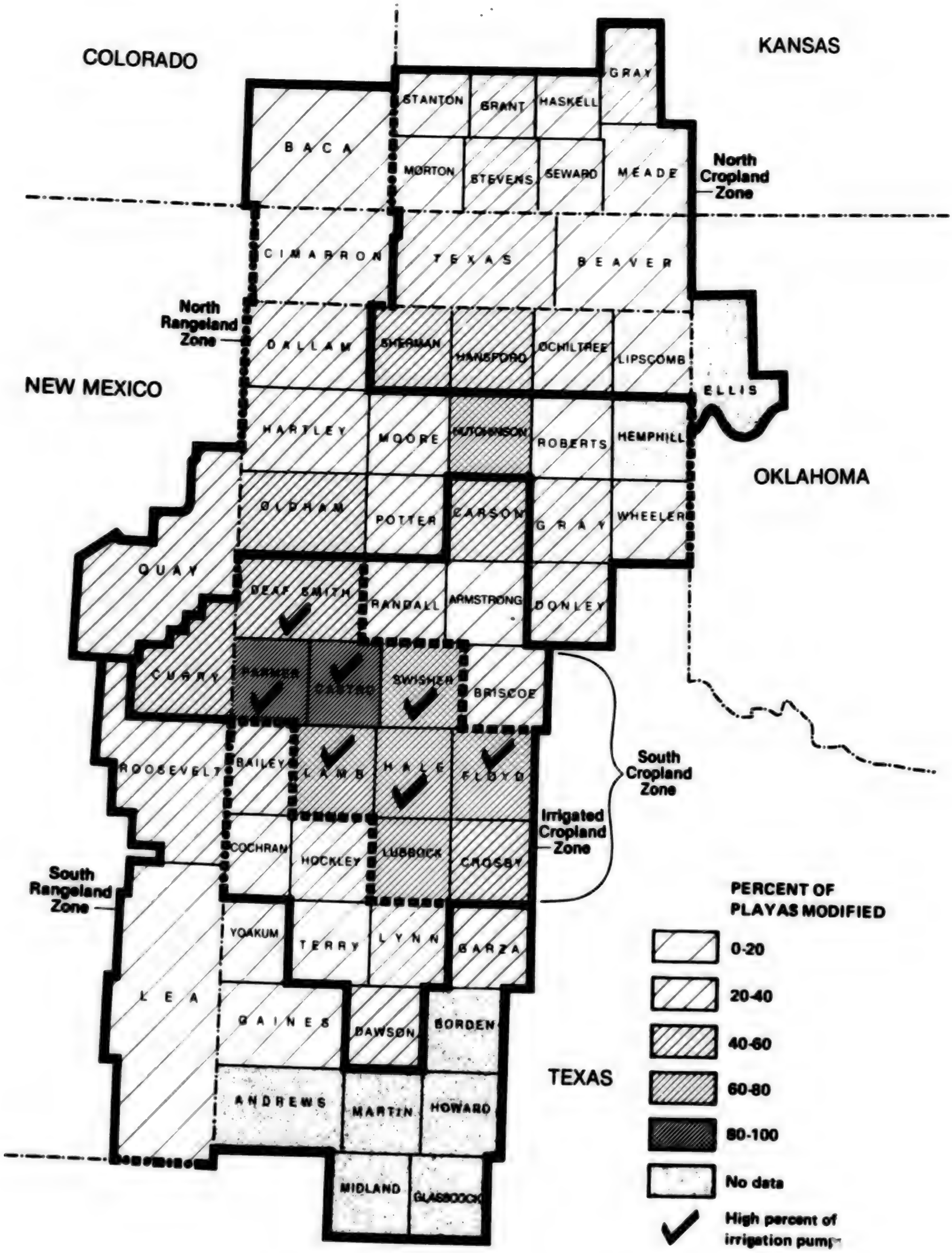

Figure 5-22. Percentage of playa basins modified, by counties within the study region (after Guthery et al. 1981).

Modification Rates and Trends. Modifications to playas began in the late 1940's when high farm commodity prices encouraged farmers to increase production (Green 1972). In 1965, only 0.6% of the playas in 44 counties of the Texas High Plains were modified (Schwiesow 1965). By 1981, 43% of the playas in 52 counties were modified, representing an increase from 150 to 10,800 modified playas in 16 years. Guthery's associates interviewed U.S. Soil Conservation Service (SCS) and Agriculture Stabilization and Conservation Service (ASCS) personnel to obtain an indication of recent trends in modification rates (Guthery et al. 1981). The results indicated that modifications were still on the increase in the Irrigated Cropland Zone, but steady or declining in the remainder of the study region. Aerial surveys produced little evidence of new modifications, suggesting that the greatly increased rate since 1965 has leveled off.

The number of playas with irrigation pumps in 1965 was 156 out of 19,241 playas in 44 Texas High Plains counties (Schwiesow 1965). A study of 37 counties by the Texas Agricultural Extension Service (Guthery et al. 1981) concluded that, by 1969, 2,955 playas had pumps installed. The trend between 1969 and 1977, however, shows a leveling off (on the average).

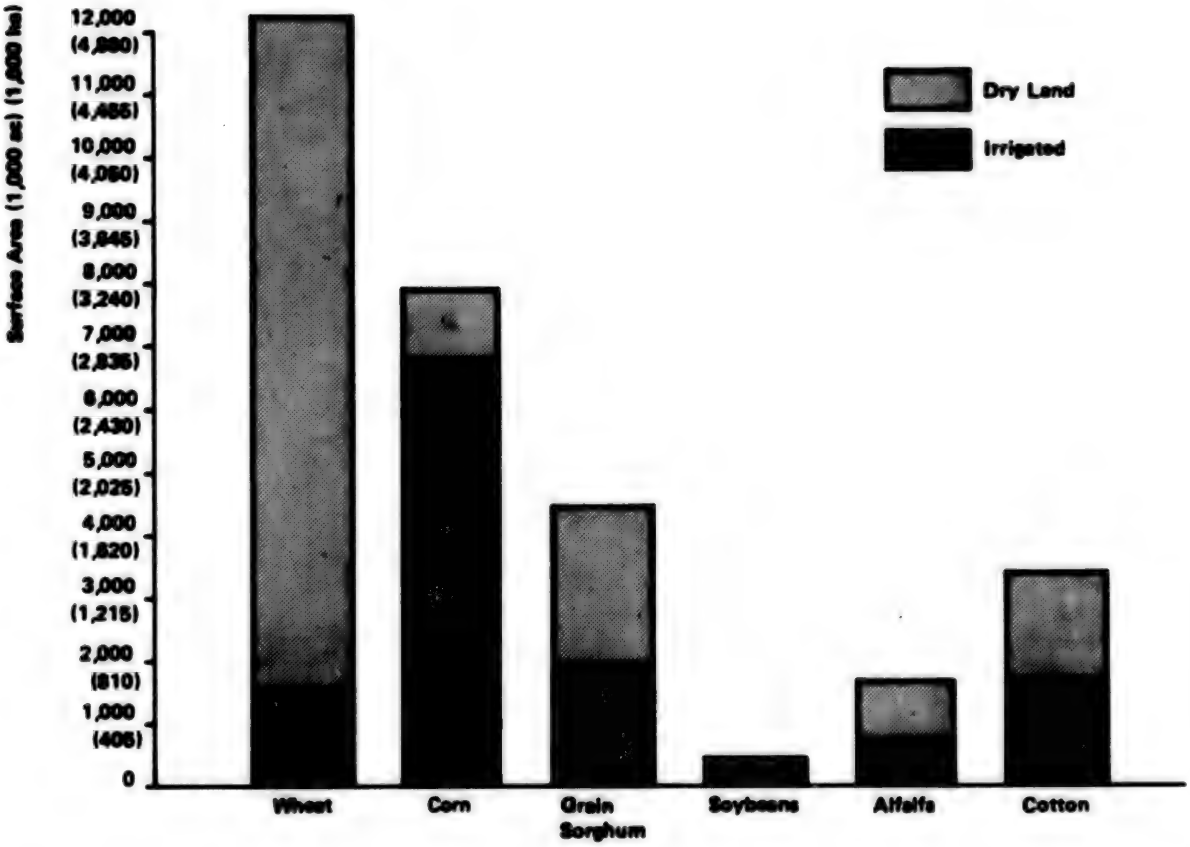

Figure 5-23. Irrigated and dry land crop distributions within the Southern Great Plains in 1977 (Banks, Feeley and Banning 1981).

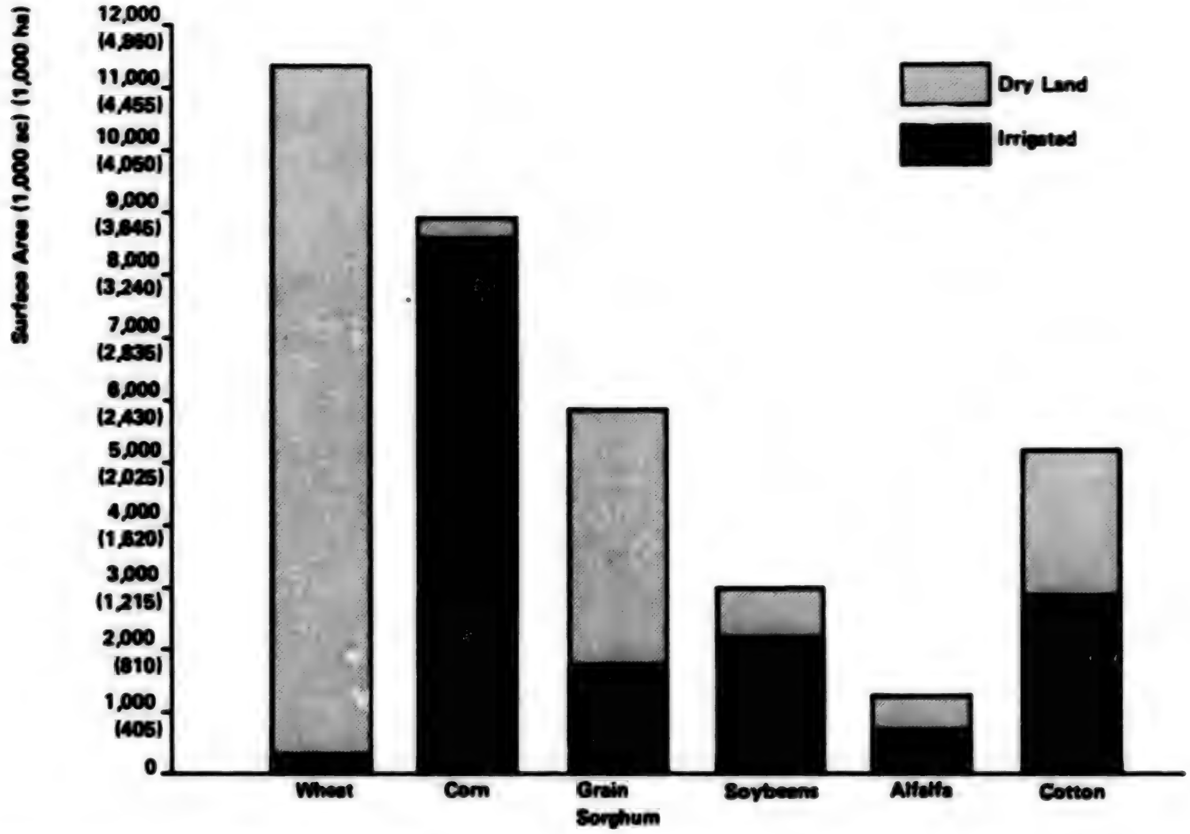

Figure 5-24. Irrigated and dry land crop distributions forecast for the Southern Great Plains in the year 2020 (Banks, Feely and Banning 1981).

Influence of Declining Aquifer Supplies. The Texas Water Development Board predicts that in some intensively irrigated areas of the Texas High Plains the Ogallala Aquifer will be almost depleted by the year 2000 (Templer 1978). Projections from the Six-State High Plains-Ogallala Aquifer Regional Resources Study (Banks, Feely and Banning 1981) show a return to dry land farming by 2020 of nearly 5.9 x 10^6 ac (2.4 x 10^6 ha) that are currently irrigated.

The forecast shrinkage in irrigation water use indicates almost a total loss of water available for irrigation in some parts of Texas and Kansas. A concurrent increase in use of irrigation water is forecast for Nebraska where natural aquifer recharge is greater. The expected decrease in irrigation water use in Texas and Kansas would be accompanied by a geographic shift in crop distributions. Acreage in corn production would increase and undergo a partial shift from northern Texas and western Kansas to parts of Nebraska where irrigation is more feasible. There would be an increase in acreage planted in grain sorghums, which can be produced on dry land or partially irrigated cropland. The acreage in wheat production would increase on a dry land basis. The forecast shifts in crop acreage between 1977 and 2020 have been represented graphically (Figures 5-23 and 5-24).

6.0 IMPACTS ON PLAYA WILDLIFE HABITAT

Some features of crop, livestock and petroleum production have had negative impacts on wildlife habitats at playa basins. In some situations, the cultivation of crops, grazing of cattle, and modification of playa basins to increase the irrigation water supply have reduced habitat diversity and carrying capacity for certain wildlife populations. Waste disposal and chemical contamination by municipalities, feedlot operators and petroleum producers have degraded a few playas. On the other hand, playa wildlife communities have, in the balance, benefited from agriculture. Production of grain crops has provided an abundant food source, and collection of irrigation tailwater has increased and stabilized playa lake and wetland habitats. Certain types of playa basin modifications have increased the protection of wildlife during drought and high winds. Managed grazing has improved seed production and wildlife access, and feedlot operation has provided supplemental runoff water.

Projected trends in the impacts on playa wetlands and their associated wildlife portray a potentially poor future for these resources. Increasing scarcity and conservation of groundwater in the Texas High Plains in particular, together with changes in crop distributions throughout the Southern Great Plains, will depreciate playa habitat values. However, regional water importation schemes now under consideration might alleviate or reverse these anticipated impacts.

6.1 IMPACTS LINKED WITH CROP PRODUCTION

Three broad activities related to Southern Great Plains crop production are linked with negative impacts to resident and migratory wildlife at playa basins; these are soil cultivation, basin modification, and chemical application (Table 6-1). Soil cultivation practices having adverse effects on wildlife are basin plowing and weed control. Plowing of both playas and surrounding prairies has destroyed a great amount of regionally scarce wildlife habitat (Figure 6-1), often limiting fall and winter cover and reducing habitat carrying capacity for most wildlife species (Guthery and Bryant 1982; Rollo and Bolen 1969). Playa cultivation encourages wind erosion, suppresses semi-aquatic vegetation, and sets back vegetative communities to earlier successional stages (Bolen, Simpson and Stormer 1979).

Clean tillage practices, such as disking and burning for weed control, have eliminated a variety of wildlife habitats, ultimately increasing the relative habitat value of noncultivated playas and the dependence of wildlife on diminishing resources. Weed control during the spring decreases the production of vegetation needed for waterfowl food, cover, and nesting; fall burning destroys winter cover that is needed by both terrestrial and aquatic species (Curtis and Beierman 1980; Rollo and Bolen 1969). Furthermore, weed control practices frequently may actually perpetuate the "weed problem." Because weeds typically are lower on the successional scale and tend to require occasional disturbance to perpetuate their populations, farmers practicing "clean till" cultivation may encourage conditions favorable for invasion by crop pests (Guthery 1981a).

Basin Modifications. Modification of playa basins for reception and storage of irrigation tailwater and related land reclamation (Figure 6-2) may promote some wildlife diseases and damage playa habitat values by disrupting the habitat ecotone or zonation, reducing the diversity and interspersion of vegetative species (Bolen 1980; Ward and Huddleston 1972). Friend (1982) reported that the potential for epizootics in migratory birds could be increased due to changes in "bird use patterns." Wildlife disease, particularly avian cholera, may be increased from modifying playas to expand and concentrate water storage; birds may crowd at the

Table 6-1. Generalized negative impacts to wildlife due to playa crop production (Nelson and Associates, Inc. 1982).

Production Activity	Primary Impacts	Secondary Terrestrial Impacts	Secondary Aquatic Impacts
Soil Cultivation			
Clean tillage by plowing and disking	Reduces persistent semi-aquatic and terrestrial plant communities. Sets back vegetative succession to pioneer stage, fostering disturbance or invader plant species. Subjects soil and substrate to wind erosion.	Eliminates cover in short supply for many upland game and nongame species.	Eliminates emergent vegetation valuable as winter cover; limits invertebrate food production and breeding of overwater nesters. Depreciates habitat value and carrying capacity for wildlife dependent on wetland vegetation.
Burning for weed control	Reduces persistent terrestrial plant communities, especially when done during late fall or winter.	Eliminates cover in short supply for many upland game and nongame species.	
Basin Modification			
Excavation and diking for storm runoff and irrigation tailwater collection	Reduces water surface, substrate, littoral zone, and emergent vegetation. Limits nutrient overturn due to water level stability. Increases basin sedimentation.	Reduces habitat zonation and interspersion of cover types, decreasing cover values for many upland species	Reduces aquatic cover, food production, habitat diversity, and breeding success for many waterfowl and other wetland species. Water concentration and waterfowl crowding during drought or freezing increases potential for fowl cholera.
Chemical Application			
Herbicide and pesticide use	Increases water contamination. Increases potential organic enrichment of substrate.	Increases potential toxicity for exposed wildlife.	Increases potential toxicity for exposed wildlife. Substrate enrichment enhances conditions favoring botulism among waterfowl.

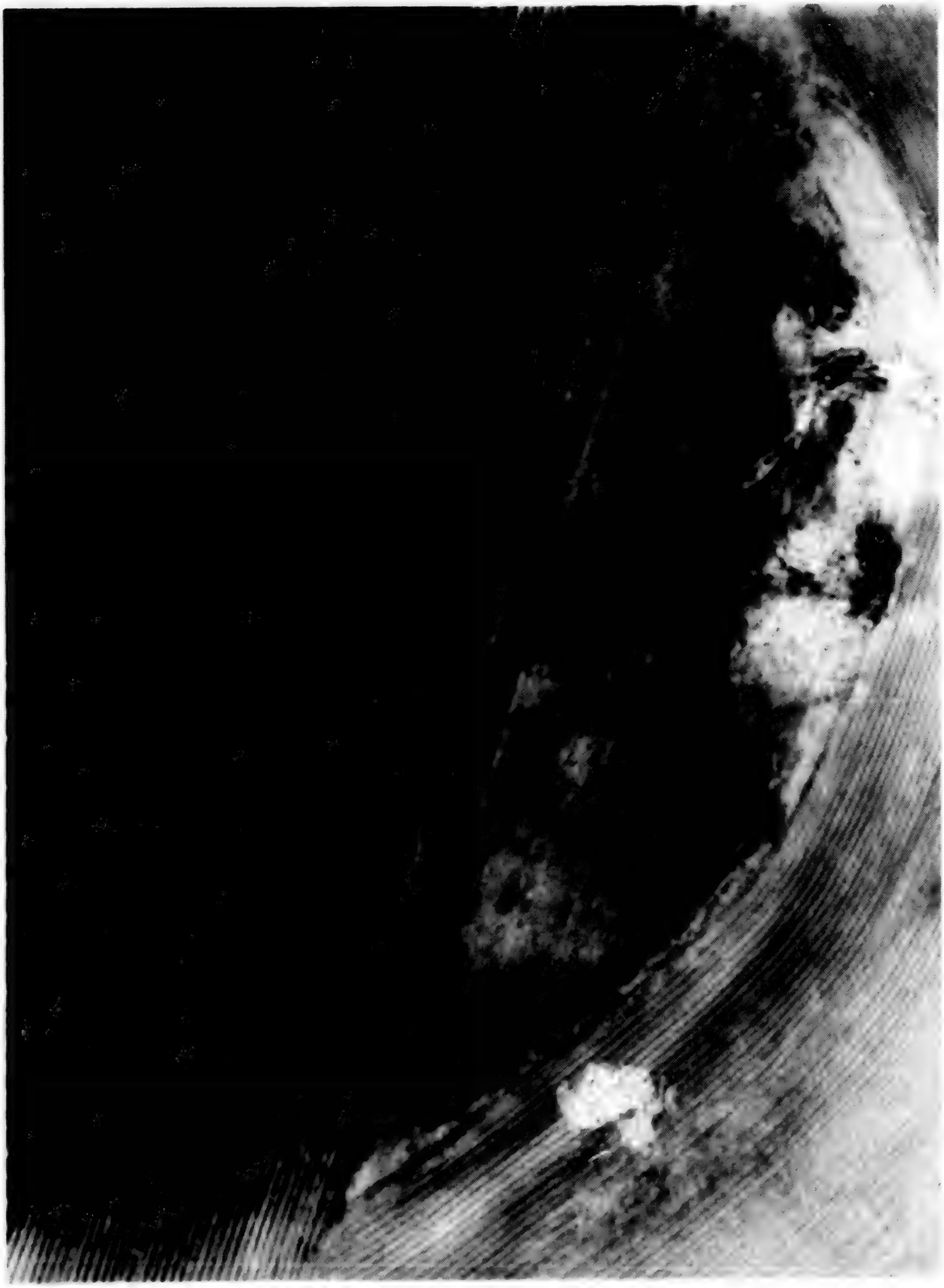

Figure 6-1. Except for a semi-natural remnant at the center depression of this playa basin, most of the wildlife habitat value has been destroyed. Remaining unplowed portion is occupied by patches of tall disturbed forbs and mudflat, evidencing past plowing throughout the basin (Texas Tech University, Department of Range and Wildlife Management 1981).

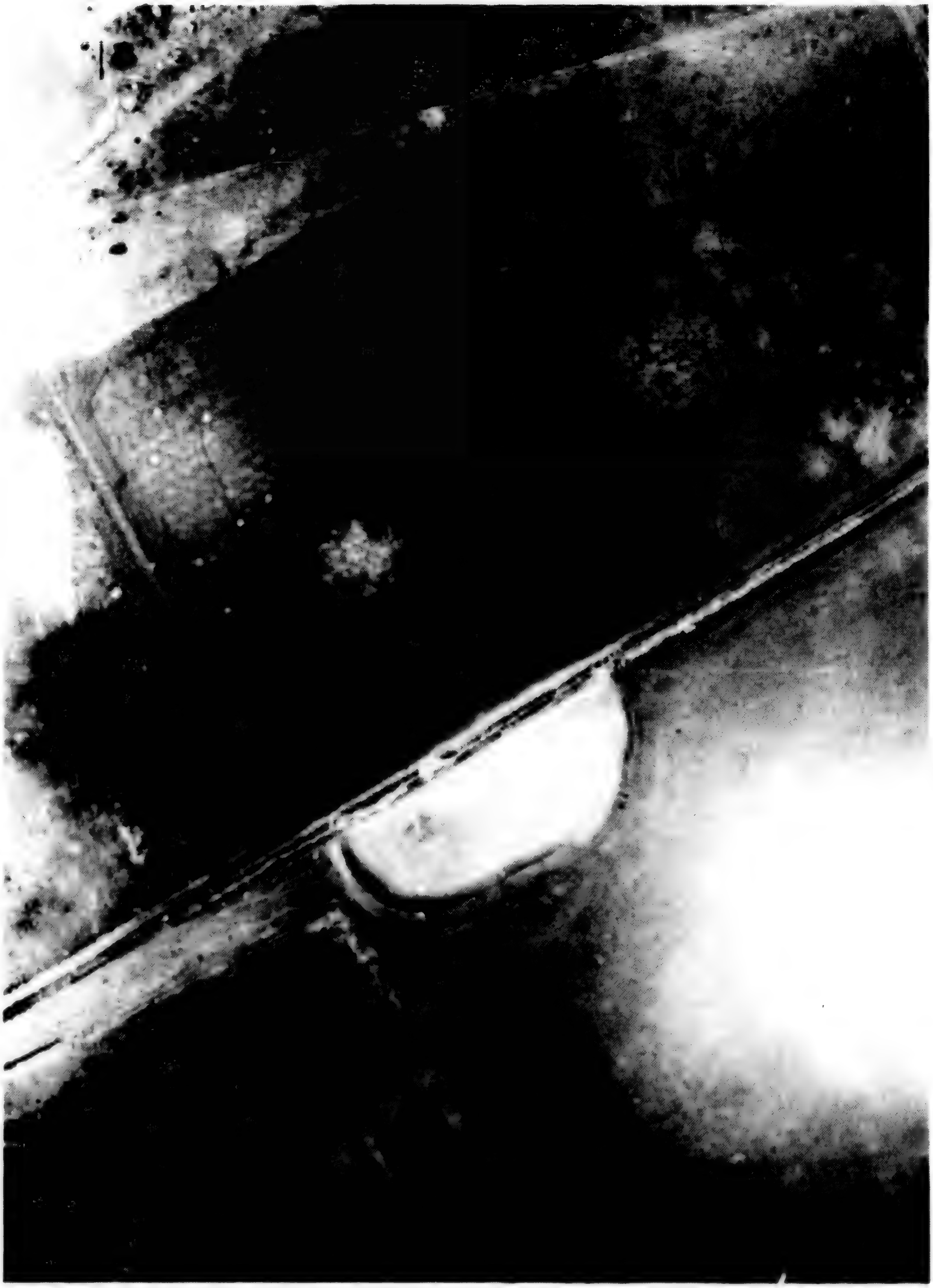

Figure 6-2. Modification for irrigation tailwater collection and storage is shown at the center of this playa basin where substantial excavation and diking concentrate the impounded water, allowing reclamation of surrounding land for crop production (Texas Tech University, Department of Range and Wildlife Management 1981).

modified playas during periods of drought and extreme cold, thereby enhancing the spread of disease. Pence (1981) noted, however, that modifications reducing the shallow aquatic area can lower the frequency and severity of botulism, encephalitis, and schistosomiasis.

Playa modifications to increase water depth and decrease water surface will reduce the biologically productive littoral zone (Figure 6-3). Shrinking the littoral zone can diminish the growth of plankton and emergent vegetation and potentially damage the foundation of the aquatic food web, thereby decreasing the overall habitat carrying capacity. Bolen, Simpson and Stormer (1979) noted that many modified playas have somewhat stabilized water levels and are less subject to periodic drying. This factor suppresses nutrient release by oxidation, tending to inhibit the production of emergent vegetation and related invertebrate biomass. Ward and Huddleston (1972) concluded that clean shorelines, monoculture of the reclaimed lake bed, and the reduced productivity of modified playa basins all tend to decrease the abundance and diversity of playa wildlife.

Waterfowl breeding success, particularly for overwater nesters, may be influenced adversely by playa modification; steep sides of excavated lakes decrease the littoral vegetation required for cover, nesting material, and substrate used by crustaceans and insects which are the preferred food of broods and brood hens (Pence 1981). Three papers report that unmodified playa basins produce substantially more total cover than modified playas, as well as a greater abundance and diversity of aquatic invertebrates and increased waterfowl brood use (Simpson and Bolen 1981; Rhodes 1978). Modified playas may be used more for waterfowl loafing than for feeding because of the limited food production. Consequently, higher waterfowl populations may be observed resting at modified basins.

Chemical Application. Some degree of playa contamination resulting from use of agricultural chemicals has occurred and will continue because these basins constitute the regional drainage system, concentrating nearly all of the Southern Great Plains surface runoff. Pesticides, herbicides, and fertilizers may reach the playa basins via runoff or through direct application in mosquito and weed control. Concentrations of these compounds vary from basin to basin, depending on the source concentrations and extent of the drainage area. Early studies of playa water contamination determined agricultural sources to be minor as most water samples had chemical concentrations well below established drinking water standards (Wells, Rekers and Huddleston 1970). Current effects of agriculturally induced pollution on playa-dependent wildlife are poorly understood, although substrate organic enrichment because of fertilizer may have raised waterfowl morbidity and mortality by favoring conditions promoting botulism (Pence 1981). Considering that present pesticides and herbicides are more biodegradable than previously, and that higher costs are encouraging more restrained use, these contaminants may pose a lesser threat than in the past.

6.2 IMPACTS LINKED WITH LIVESTOCK PRODUCTION

Adverse impacts to playa wildlife populations that are linked to livestock production revolve around grazing practices and feedlot operations (Table 6-2). Livestock production activities per se do not adversely impact playa habitats; it is more the intensity and timing of the activity that creates problems for wildlife. Grazing at playa basins may be continuous, seasonal, or absent (Guthery 1981a).

Continuous year-round grazing has major adverse effects on the health and production of some forbs and grasses, while seasonal grazing that is managed by fencing the basin can avoid considerable damage to wildlife cover. Late fall and winter grazing can destroy valuable cover and expose soil to wind

Figure 6-3. Excavating and diking at the edge of a playa basin to increase storage capacity and reduce evaporation can shrink the productive littoral zone, diminish emergent vegetation, and damage the aquatic food web (Nelson and Associates, Inc. 1981).

erosion, ultimately suppressing the vegetative production at that site (Simpson et al. 1981). Growth of playa vegetation is stunted by fall burning followed by spring grazing, although this management practice may be sound for some species. Another factor in diminishing playa vegetation is the trampling that occurs at the lake margin when cattle drink; this problem is more severe at the limited margin of modified playas (Bolen, Simpson and Stormer 1979). Perhaps one consequence of playa grazing is that shortgrass communities are promoted at the expense of midgrasses (Figure 6-4) (Guthery, Pates and Stormer 1982).

The intensity of grazing at playas is another consideration in gauging the impact. Light grazing may be useful on densely vegetated playas to open wildlife travel lanes. Heavy grazing can cause multiple adverse impacts on wildlife habitats; changes in habitat physiognomy will reduce the carrying capacity, winter cover and nesting cover for both waterfowl and terrestrial species such as pheasant (Guthery, Custer and Owen 1980; Taylor 1980; Whyte 1978). Neal and Motts (1967) reported that overgrazing decreases surface water infiltration and increases runoff and wind erosion, effects which contribute to negative impact on playa habitats.

Operation of Feedlots. Feedlot operations can have negative effects on playa habitats. Organic pollution from feedlot wastes can reduce water quality and promote disease organisms (Pence 1981). Friend (1982) points out the potential contamination of feedlot effluent and runoff with a variety of disease agents, posing a disease hazard to exposed wildlife. Lehman (1972) suggested that the low permeability of playa basins may become even lower following exposure to feedyard runoff; this factor could be responsible for enhancing the anaerobic environment favored by botulism bacteria. Lehman, Stewart and Mathers (1970) recognized that groundwater may be contaminated when feedlot runoff and impounded wastes pass through the more permeable, sloping

Table 6-2. Generalized negative impacts to wildlife caused by playa livestock production (Nelson and Associates, Inc. 1982).

Production Activity	Primary Impacts	Secondary Terrestrial Impacts	Secondary Aquatic Impacts
Livestock Grazing			
Overgrazing and trampling	Suppresses health and production of some forbs and grasses. Reduces taller herbaceous vegetation, promoting shortgrass communities.	Reduces upland cover and food values for some wildlife due to close cropping and suppression of seed production. Reduces upland cover for some species, particularly winter and nesting cover for game birds and nesting cover for some waterfowl.	Reduces wetland littoral zone vegetation used as winter, escape and nesting cover by a variety of wildlife.
Feedlot Operations			
Organic waste impoundment	Increases organic enrichment of substrate.		Wetland substrate enrichment supports conditions favoring botulism.

soils at the periphery of playa basins; small, deep playas located in the coarse-textured soil region are at greatest risk to this contamination. Surface water contamination could impair the health of exposed wildlife populations.

6.3 IMPACTS LINKED WITH PETROLEUM PRODUCTION

A variety of organic, inorganic, carcinogenic, toxic, and noxious substances have been disposed within playa basins by individuals, municipalities, industries, and military agencies (Pence 1981; Guthery and Stormer 1980). Disposal in playas of garbage, junk, sewage, and other wastes having limited toxicity produces obvious aesthetic impact, can degrade water quality, and may promote wildlife disease or cause physical injury to some animals. The most widely reported playa pollution sources linked to waterfowl mortality and habitat degradation are crude oil spills and dumping of oil well brine by the petroleum industry. Pollution from well or pipeline leaks of crude oil and disposal of contaminated brine present a hazard to wildlife at particular playas. Over 10,000 chemicals including acids, caustics, rust inhibitors, and heavy metal compounds, the majority of which are lethal to wildlife, may be found in the chemical-laden oil field brine (Erskine 1981). However, there is little documentation of wildlife morbidity or mortality associated with these chemicals.

Aside from direct mortality and weakening of waterfowl, the effects of by-products from petroleum production on wildlife morbidity are poorly understood (Pence 1981). Disposal of oil field brine has been reported to cause injury and death to contaminated wildlife, damage to surrounding vegetation and beaches, and contamination of groundwater (Pence 1981; Brewster 1979; Vogler 1979). Death has resulted to waterfowl from coating and ingestion of oil (Nava 1977).

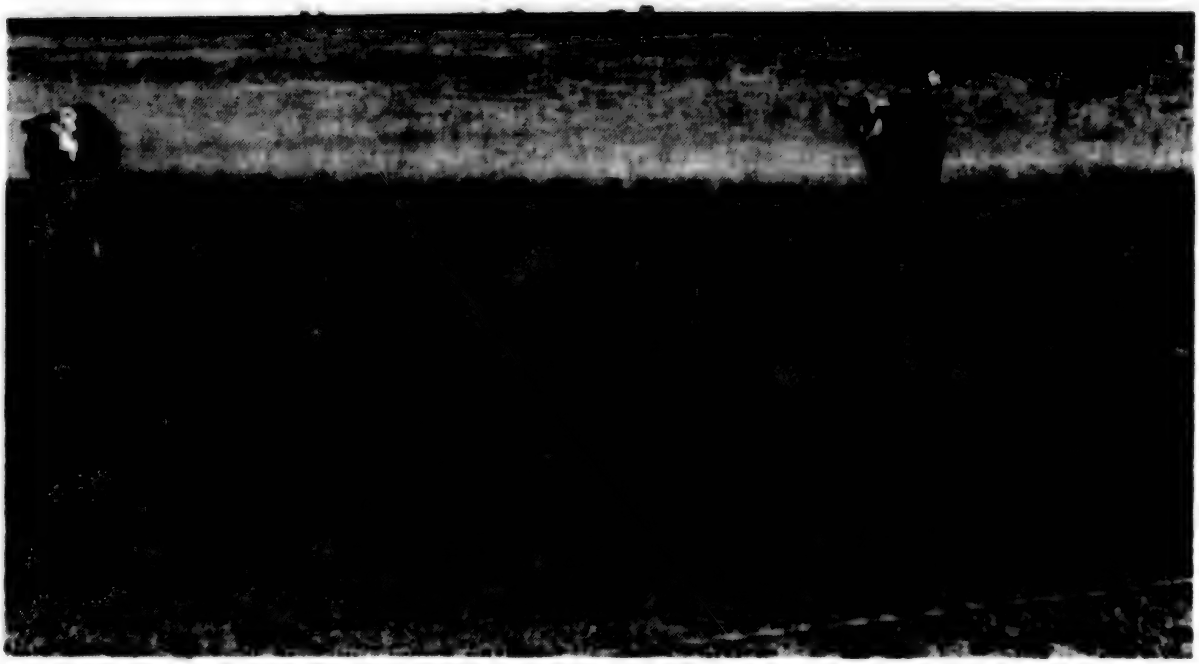

Figure 6-4. Grazing of cattle at the shorelines of playa lakes can suppress vegetative growth valuable as wildlife food, cover and nesting sites, preserving the shortgrass communities instead (Nelson and Associates, Inc. 1981).

Salt encrustation from brines can lead to drowning, freezing, or easy predation. Erskine (1981) reported that diving birds cannot survive encounters with petroleum brine wastes, and that nondiving birds seldom survive overnight contact. Pence (1981) noted that oil field brine containing concentrations of crude oil and grease meeting legal standards does not present a proven hazard to wildlife where brine is deposited in natural saltwater playas. Another negative aspect of brine disposal is that this practice maintains a high water level in what otherwise would be a dry playa; a highly attractive, yet potentially harmful habitat is made available through this disposal operation.

Reported waterfowl losses due to oil field brine disposal are confined to five lakes in the Texas High Plains: Whalen and Lost Lakes, Andrews County; Cedar Lake, Gaines County; Mound Lake, Terry and Lynn Counties; and Soda Lake, Crane County (Brewster 1979). Among these lakes, Lake Whalen is most thoroughly investigated and documented. According to Nava (1977), Whalen Lake was once heavily inhabited by wildlife, especially migratory waterfowl, and provided an excellent resource for sportsmen. The first bird kill due to petroleum waste in this lake was reported in the fall of 1972; since then conditions gradually have deteriorated, and a hazard exists for the reduced populations still using this playa. Vogler (1979) reported levels of hydrocarbon pollution at Lake Whalen ranging from 176 to 481 ppm, as compared to the Texas Railroad Commission standard limitation of 20 ppm.

6.4 BENEFITS FROM CROP AND LIVESTOCK PRODUCTION

Several features of crop and livestock production beneficially influence wildlife habitats for selected populations. Certain crop farming practices may promote wildlife and provide food, cover and water that might otherwise not be available. Managed grazing can improve the persistence of wildlife cover and may encourage habitat favored by certain species to flourish. The positive impacts of crop and livestock production activities have been summarized (Table 6-3).

Migratory and resident wildlife benefit from Southern Great Plains crop production. As the irrigated row crops (corn and sorghum) ripen, wintering waterfowl depend on them as their main food source (Simpson et al. 1981). Waste corn, available from harvest, is particularly important as it comprises over 90% of fall and winter diets of the region's mallard, pintail, teal, and other waterfowl populations (Moore 1980). Resident wildlife benefit from irrigated crop production, especially those animals dwelling in basins surrounded by grain crops rather than vegetables or cotton (Guthery 1981a). Ring-necked pheasant exhibit the highest densities near playas surrounded with irrigated crops; they benefit mainly from the easy availability of diet staples--waste corn and other grains (Bolen and Guthery 1982; Guthery, Pates and Stormer 1982). Simpson et al. (1981) observed that playa-produced seeds (spikerush, barnyard grass, and pondweed) have assumed less importance as waterfowl foods and probably could not support present populations.

Reception of Irrigation Tailwater. Playa basins that receive irrigation tailwater are usually larger, yield more wildlife cover, and provide better habitat than those found on rangeland or on croplands without irrigation. Adverse impacts on playas from agricultural land use may be offset by tailwater reception because the augmented moisture regime causes aquatic habitats to persist for longer periods and provides greater habitat diversity. The additional water surface and depth, particularly during a drought, increase aquatic substrate and emergent vegetation, improving habitat conditions for waterfowl roosting, breeding, and for nesting of redheads (overwater nesters). Basins that receive tailwater provide more ecotone (edge effect) because of greater vegetative interspersion as well as diversity and abundance of suitable cover (Guthery,

Table 6-3. Generalized positive impacts to wildlife due to playa crop and livestock production (Nelson and Associates, Inc. 1982).

Production Activity	Primary Impacts	Secondary Terrestrial Impacts	Secondary Aquatic Impacts
Soil Cultivation			
Growing crops	Produces grains used by many avian and several mammalian species as a food source (especially corn). Increases nutrient levels in the playa basin.	Increases carrying capacity of upland habitat.	Increases carrying capacity of adjacent wetland habitat, particularly for waterfowl. Increases diversity and biomass of wetland vegetation, enhancing cover and natural food production.
Crop Irrigation			
Tailwater collection	Provides additional water surface and depth, especially during dry periods. Increases nutrient levels due to dissolved fertilizer. Increases emergent vegetation and vegetative diversity and biomass.	Increases ecotone and upland habitat diversity. Increases habitat carrying capacity for selected upland wildlife.	Increases wetland cover, substrate, and food production. Increases waterfowl roosting, breeding and nesting habitat.
Basin Modification			
Excavation and diking for storm runoff and irrigation tailwater collection	Preserves some open water in periods of drought. Vegetated spoil banks increase habitat diversity.	Provides drinking water for upland wildlife during drought. Increases nesting and denning sites and travel lanes for upland wildlife. Increases protection from high winds.	Maintains some wetland habitat during drought, particularly for resting waterfowl. Helps to control botulism in waterfowl.
Feedlot Operations			
Runoff collection	Provides additional water surface and depth, especially during dry periods.	Provides drinking water for upland wildlife during dry periods.	Increases resting sites for wintering waterfowl.

Table 6-3. (concluded)

Production Activity	Primary Impacts	Secondary Terrestrial Impacts	Secondary Aquatic Impacts
Livestock Grazing			
Managed seasonal grazing	Promotes some seed-producing vegetation if done early in spring. Improves wildlife access and habitability in dense vegetation.	Provides a natural food source for upland wildlife, particularly game birds. Opens travel lanes needed by some upland game birds and smaller mammals.	Enhances wetland breeding habitat for selected wildlife, particularly some shorebirds.

Pates and Stormer 1982). The zonation and variety of habitat types that may be made available in playa basins because of tailwater reception are evident from aerial photographs (Figure 6-5).

The average area of playa vegetation suitable for wildlife has been up to 29 times greater at certain basins strictly as a result of tailwater collection (Guthery 1980; Pates, Guthery and Stormer 1980). Guthery and Stormer (1980) recognized that irrigation tailwater *cultures* wetlands in the semiarid Southern Great Plains. Tailwater addition to playa basins promotes an abundance of wetland vegetation including pondweed, smartweed, devilweed, cattail, bulrush, arrowhead, and water clover; some of these species would rarely occur without tailwater input (Guthery, Pates and Stormer 1982; Guthery 1981a). Because tailwater bears nutrients from fertilizers applied to croplands, playas intercepting this water tend to have lush vegetation, dense cover, and increased seed production (Simpson and Bolen 1981).

Modifications to Concentrate Water. Playa modification by pitting and trenching and diking for runoff concentration and tailwater collection has a variable impact on wildlife as habitats may result ranging in value from excellent to marginal depending upon playa size, volume of soil excavated, and availability of required habitat components that are species-specific (Pates, Guthery and Stormer 1980; Neal 1965). The main contribution of these basin modifications is to preserve some open water and aquatic habitat during drought, thereby providing some nesting sites for waterfowl. Pit excavations and spoil banks (Figure 6-6) can also improve terrestrial habitat, especially for pheasant nesting and raccoon denning, although average open water habitat is decreased (Guthery, Pates and Stormer 1982; Taylor 1980). Naturally vegetated high banks constructed around excavated pits or trenches can improve protection from severe weather, particularly from high winds (Simpson et al. 1981).

Grazing and Feedlot Operations. Managed grazing can be beneficial to wildlife habitats, and seasonal grazing generally results in less damage to wildlife cover. Moderate spring grazing can promote growth of annual forbs, the seeds of which supply food for wildlife (Guthery, Pates and Stormer 1982; Simpson and Bolen 1981). Where dense, tangled vegetation may develop in playa basins that preserve very ample moisture, moderate grazing will open the vegetative cover, improve access for pheasant and other terrestrial species, and enhance cover (Guthery 1981a; Simpson and Bolen 1981). Concentration of playa water by basin modification, along with collection of cattle feedlot runoff, further increases water availability during summer, winter, and periods of drought, helping to sustain aquatic environment and furnish refuge to waterfowl and resident wildlife (Rollo and Bolen 1969; Buller 1964).

6.5 DISEASE CONTROL BENEFITS

Modification of playa basins can result in less frequent or intense epizootics of encephalitis, schistosomiasis, and botulism, thereby reducing the extent of wildlife mortality. Pitting or trenching large basins to concentrate runoff will substantially reduce wetland area, minimizing the breeding habitat of encephalitis-bearing mosquitos (Ward and Huddleston 1972; Grubb, Parks and Sciple 1968). Reduction of playa wetland surface area decreases mud flats and littoral edge habitats favored by other invertebrates, including schistosomiasis-bearing snails (Pence 1981; Traweek 1981). Bolen and Guthery (1982) suggest that control of playa water levels to maintain inundation and open water during seasons critical for botulism and cholera epidemics can reduce the incidence of these diseases. Harmston et al. (1956) noted, however, that the health benefits of basin alteration, while attainable, do not by themselves justify the costs of modification.

Figure 6-5. Reception of irrigation tailwater (note multiple runoff channels) within this playa basin promotes vegetative zonation and habitat diversity, ranging from shortgrasses, short disturbed forbs, and wet meadow around the basin periphery to broad-leaved emergents and open water at the basin interior (Texas Tech University, Department of Range and Wildlife Management 1981).

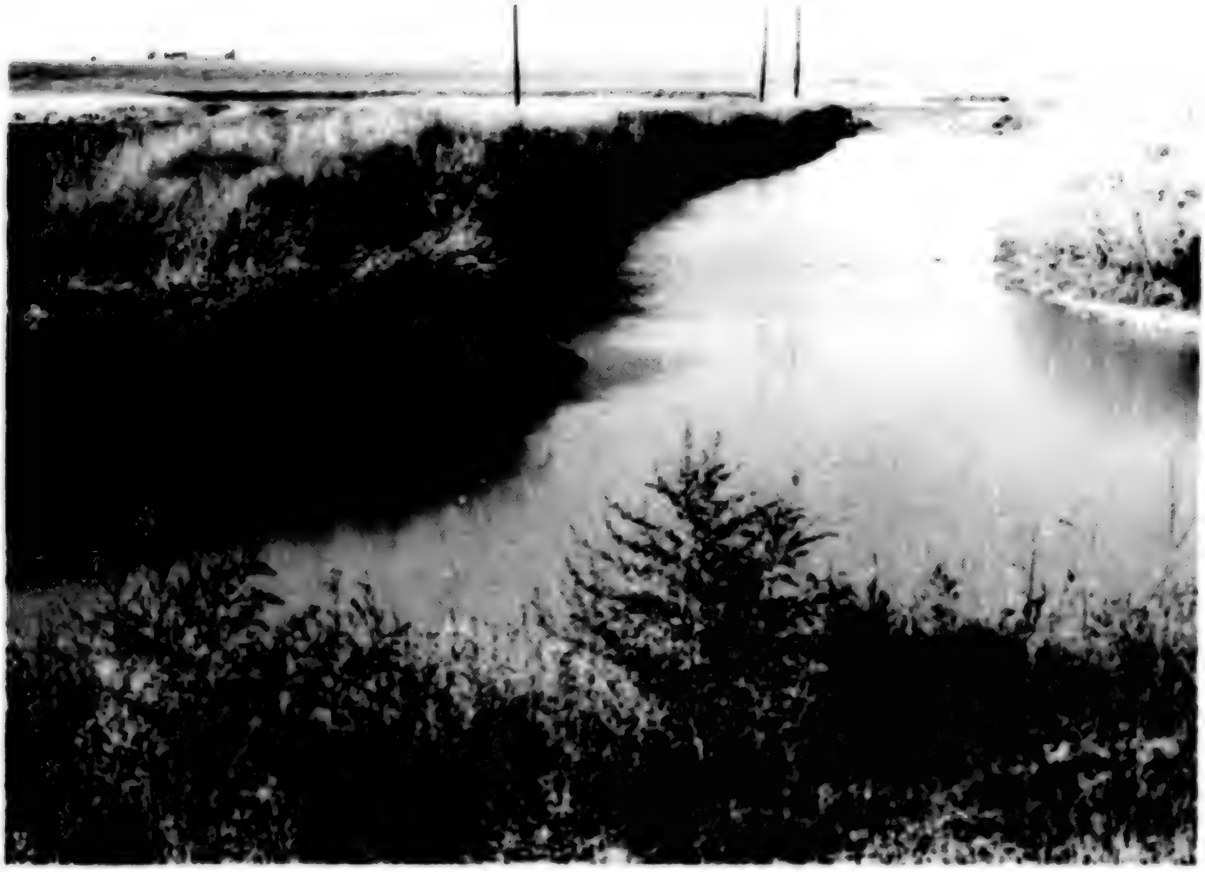

Figure 6-6. Pit or trench excavations and the accompanying spoil banks may create improved terrestrial habitat, particularly for pheasant nesting and raccoon denning, with increased protection from severe weather (Nelson and Associates, Inc. 1981).

6.6 PROJECTED TRENDS FOR PLAYA LAKES AND WETLANDS

Present trends indicate major changes in the availability of groundwater and the pattern of related crop production in the Southern Great Plains. Projected depletion of the Ogallala Aquifer, allied with increasing energy costs for pumping irrigation water from deeper wells, should force implementation of water conservation measures, encourage cultivation of crops that return higher income, and ultimately change land use patterns (Banks, Feely and Banning 1981).

Measures to decrease the evapotranspiration losses and groundwater demands will include selection of crops and methods of cultivation such as "no-till" that reduce water requirements, retention of crop residues, and contouring techniques to conserve soil moisture and retain surface runoff. Irrigation efficiency may be increased by decreasing the lengths of furrows and periods of flow, as well as the formation of dikes enclosing fields, and conversion from furrow to sprinkler irrigation (High Plains Underground Water Conservation District 1977). Taken as a whole, these water conservation measures will lead to a significant reduction in irrigation tailwater and tailwater input to playa basins (Bolen and Guthery 1982).

The reduced availability of groundwater supplies along with rising costs of pumping and irrigation will also promote the conversion of irrigated acreage to dry land farming. Irrigated acreage in the Texas High Plains is expected to decrease up to 50% from present levels by the year 2000, with a pronounced shift to dry land farming in most of the Southern Plains by 2020 (U.S. FWS 1981). Returning an estimated six million irrigated acres (2.4 million hectares) of cropland, primarily in Texas and Kansas, to dry land cultivation by 2020 would result in a decrease of irrigated cereal grain production up to 99% and a concurrent increase in cotton and dry land wheat and grain sorghum acreage (Banks, Feely and Banning 1981).

Projected Changes for Wildlife Habitats. Expected reductions of aquifer supplies for irrigation and the related conversion to sprinkler irrigation and dry land cultivation, particularly in the Texas High Plains, indicate a decline in playa lake and wetland wildlife habitat values. Projected reductions in regional grain production, especially corn, and irrigated acreage are expected to decrease playa habitat carrying capacity and related wildlife abundance within the Southern Great Plains (Simpson and Bolen 1981). Decreasing irrigation and more efficient methods will reduce the stability of playa wetlands because of a decline in tailwater, causing them to be more vulnerable to environmental stresses (Bolen and Guthery 1982). Playas that are now flooded, even in dry years, by irrigation tailwater may no longer receive this water, thus reducing their habitat value considerably, especially as winter cover for waterfowl, pheasant, and other wildlife.

There are some plans to modify certain large playa basins for storage of *imported* water that may, if carried through, partially offset the impacts of water shortages and conservation practices on wildlife dependent on the supply of irrigation tailwater (Brabander 1981). The presence of imported water in playas could maintain the current mix of crops which provide waste grains for wildlife. Bolen, Simpson and Stormer (1979) concluded that, without the water imports, the quality of playa habitats and the current abundance of wildlife supported by these lakes and wetlands are likely to decline.

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APPENDIX A

Plants of Playas and Associated Habitats in the Southern High Plains (Llano Estacado) Study Area of Curtis and Beierman (1980).

Scientific Name	Common Name
FAM. EQUISETACEAE	
Equisetum arvense	Common horsetail
FAM. MARSILEACEAE	
Marsilea mucronata	Hairy pepperwort
FAM. TYPHACEAE	
Typha latifolia[1]	Common cattail
FAM. POTAMOGETONACEAE	
P. natans	Floatingleaf pondweed
P. pectinatus	Fennelleaf pondweed
Zannichellia palustris	Common poolmat
FAM. NAJADACEAE	
Najas flexilis	Southern waternymph
FAM. ALISMATACEAE	
Sagittaria cuneata	Northern arroweed
FAM. GRAMINEAE	
Agropyron smithii[1]	Western wheatgrass
Aristida spp.[1]	Threeawns
Bahia woodhousii	Bahiagrass
Bothriochloa saccharoides var. *torreyana*	Silver bluestem
Bouteloua barbata	Six-weeks grama
B. curtispendula	Sideoats grama
B. gracilis[1]	Blue grama
B. secalinus	Cheatgrass
Buchloe dactyloides[1]	Buffalograss
Cenchrus spp.	Sandbur
Chloris andropogonoides[1]	Windmillgrass
Cynodon dactylon	Common bermudagrass
Echinochloa crusgalli[1]	Barnyardgrass
Elymus canadensis[1]	Canada wildrye
Eragrostis cilianensis	Stinkgrass
E. intermedia	Plains lovegrass
Hilaria mutica	Tobosa
Hordeum jubatum[1]	Foxtail barley
Leptochloa sp.	Sprangletop
Muhlenbergia arenicola	Sand muhly
Panicum capillare[1]	Common witchgrass
P. hallii	Hall's panicum

APPENDIX A (continued)

Scientific Name	Common Name
FAM. GRAMINEAE (continued)	
P. virgatum[1]	Switchgrass
P. obtusum	Vine mesquite
Schizachyrium scoparium	Little bluestem
Schleropogon brevifolius	Burrograss
Setaria italica	Foxtail bristlegrass
S. viridis	Green bristlegrass
Sorghum halepense[1]	Johnsongrass
S. vulgare var. *technicum*	Sorghum
Spartina pectinata	Prairie cordgrass
Sporobolus airoides	Alkali sacaton
S. asper var. *hookeri*	Meadow dropseed
S. cryptandrus	Sand dropseed
S. poiretii	Rattail smutgrass
Triticum aestivum[1]	Wheat
Vulpia octoflora var. *glauca*	Six-weeks fescue
Zea mays var. *indentata*[1]	Field corn
FAM. CYPERACEAE	
Carex spp.	Sedge
Cyperus esculentus	Chufa
Eleocharis macrostachya	Creeping spikerush
E. palustris[1]	Spikerush
Scirpus acutus	Hardstem bulrush
S. americanus	American bulrush
S. validus[1]	Softstem bulrush
FAM. JUNCACEA	
Juncus spp.	Rush
FAM. LILIACEAE	
Nothoscordum bivalus	Crowpoison
Yucca spp.	Yucca
FAM. SALICACEAE	
Populus deltoides	Eastern cottonwood
Salix sp.	Willow
FAM. ULMACEAE	
Celtis occidentalis	Hackberry
Ulmus parvifolia	Chinese elm
FAM. MORACEAE	
Maclura pomifera	Osage orange
Morus rubra	Red mulberry

APPENDIX A (continued)

Scientific Name	Common Name
FAM. URTICACEAE	
Urtica gracilis	Slim nettle
FAM. POLYGONACEAE	
Eriogonum spp.	Wildbuckwheat
Polygonella sp.	Jointweed
Polygonum aviculare[1]	Prostrate knotweed
P. coccineum[1]	Bigroot smartweed
P. lapathifolium	Curltop smartweed
Rumex crispus[1]	Curly dock
FAM. CHENOPODIACEAE	
Allenrolfea occidentalis	Pickleweed
Chenopodium album	Lambsquarters
Chenopodium sp.[1]	Goosefoot
Kochia scoparia[1]	Belvedere summercypress
Salsola kali[1]	Russianthistle
FAM. AMARANTHACEAE	
Amaranthus palmeri[1]	Palmer amaranth
Gossypium hirsutum	Cotton
FAM. AIZOACEAE	
Sesuvium portulacastrum	Purslane sesuvium
FAM. CRUCIFERAE	
Descurainia spp.	Tansymustard
Lepidium spp.[1]	Pepperweed
Lesquerella spp.[1]	Bladderpod
Rorippa sinuata[1]	Spreading yellowcress
Sisymbrium altissimum	Tumblemustard
FAM. LEGUMINOSAE	
Acacia greggii	Catclaw acacia
Amorpha canescens	Leadplant
Astragalus distortus	Bentpod milkvetch
Cassia fasciculata	Partridge pea
Gleditsia triacanthos	Common honeylocust
FAM. LEGUMINOSAE	
Hoffmanseggia densiflora	Indian rushpea
Lespedez striata	Japanese lespedeza
Medicago sativa	Alfalfa
Melilotus officinalis	Yellow sweetclover
Oxytropis lambertii	Lambert crazyweed
Prosopis glandulosa[1]	Honey mesquite

APPENDIX A (continued)

Scientific Name	Common Name
FAM. OXALIDACEAE	
Oxalis dillenii	Woodsorrel
FAM. ZYGOPHYLLACEAE	
Tribulus terrestris	Goathead
FAM. EUPHORBIACEAE	
Cnidoscolus texanus	Texas bullnettle
Croton spp.	Croton
Euphorbia marginata[1]	Snow-on-the-mountain
E. prostrate	Prostrate suphorbia
Stillingia sylvatica	Queensdelight
FAM. MALVACEAE	
Malva neglecta	Common mallow
Sphaeralcea spp.	Globemallow
FAM. TAMARICACEAE	
Tamarix gallica[1]	Saltcedar
FAM. CACTACEAE	
Opuntia leptocaulis	Tasajillo
Opuntia sp.[1]	Pricklypear
FAM. ONAGRACEAE	
Oenothera canescens[1]	Beakpod evening primrose
Oenothera sp.	Evening primrose
FAM. ASCLEPIADACEAE	
Asclepias syriaca	Milkweed
Asclepias sp.	Milkweed
FAM. CONVULVULACEAE	
Calystegia sepium	Hedge bindweed
Convolvulus arvensis	Field bindweed
Cuscuta gronovii[1]	Dodder
FAM. BORAGINACEAE	
Heliotropium curassavicum	Salt heliotrope
FAM. VERBENACEAE	
Phyla incisa[1]	Sawtooth fogfruit
Verbena bracteata[1]	Bigbract verbena
FAM. LABIATAE	
Salvia spp.	Sage

APPENDIX A (concluded)

Scientific Name	Common Name
FAM. SOLANACEAE	
Physalis heterophylla	Clammy groundcherry
Solanum elaeagnifolum[1]	Silverleaf nightshade
S. rostratum[1]	Buffalobur
FAM. SCROPHULARIACEAE	
Linaria vulgaris[1]	Common toadflax
FAM. MARTYNLACEAE	
Martynia louisianica	Common devilclaws
FAM. PLANTAGINACEAE	
Plantago aristata	Bottlebrush plantain
FAM. RUBIACEAE	
Diodia teres	Rough buttonweed
FAM. CUCURBITACEAE	
Cucurbita foetidissima	Buffalogourd
FAM. COMPOSITAE	
Ambrosia artemisiifolia	Common ragweed
A. cheiranthifolia	Ragweed
A. psilostachya[1]	Western ragweed
A. trifida	Giant ragweed
Aster spp.	Aster
Berlandiera sp.	Greeneyes
Cirsium arvense	Thistle
Coreopsis tinctoria	Plains coreopsis
Croptilon sp.	Croptilon
Engelmannia pinnatifida	Engelmann daisy
Erigeron canadensis[1]	Fleabane
Grindelia squarrosa[1]	Broadleaf gumplant
Helianthus cilliaris[1]	Blueweed sunflower
H. decapetalus[1]	Sunflower
Helianthus sp.	Sunflower
Hymenoxys odorata	Western bitterweed
Iva sativa	Sumpweed
Lactuca serriola	Prickly lettuce
Ratibida peduncularis var. *tagetes*[1]	Shortray prairie-coneflower
Senecio longilobus	Threadleaf groundsel
Sonchus oleraceous	Common sowthistle
Tragopogon porrifolius	Vegetable-oyster salsify
Xanthium strumarium	Cocklebur
Xanthocephalum sp.	Broomweed

[1] Indicates most commonly noted

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APPENDIX B

Birds of Playas and Associated Habitats in the Southern High Plains (Llano Estacado) Study Area of Curtis and Beierman (1980).

Scientific Name	Common Name
FAM. PODEIPEDIDAE	
Podihymbus podiceps[1]	Pied-billed grebe
Podiceps caspicus	Eared grebe
FAM. ANATIDAE	
SUB. FAM. ANSERINAE	
Branta canadensis	Canada goose
Anser albifrons	White-fronted goose
Chen caerulescens	Snow goose
SUB. FAM. ANATINAE	
Anas platyrhynchos[1]	Mallard
A. acuta[1]	Pintail
A. strepera	Gadwall
Mareca americana[1]	American wigeon
Spatula clypeata[1]	Shoveler
Anas discors[1]	Blue-winged teal
A. cyanoptera	Cinnamon teal
A. carolinensis	Green-winged teal
SUB. FAM. AYTHYINAE	
Aythya americana[1]	Redhead
Aythya valisineria	Canvasback
SUB. FAM. OXYURINAE	
Oxyura jamaicensis	Ruddy duck
FAM. CATHARTIDAE	
Cathartes aura	Turkey vulture
Coragyps atratus	Black vulture
FAM. ACCIPITRIDAE	
Circus cyaneus[1]	Marsh hawk
Buteo lagopus	Rough-legged hawk
B. regalis	Ferruginous hawk
B. Swainsoni	Swainson's hawk
Aquila chrysaetos	Golden eagle
Haliaeetus leucocephalus	Bald eagle
FAM. FALCONIDAE	
Falco mexicanus	Prairie falcon
F. peregrinus	Peregrine falcon
F. sparverius	American kestrel
FAM. MELEAGRIDIDAE	
Meleagris gallopavo	Turkey

APPENDIX B (continued)

Scientific Name	Common Name
FAM. TETRAONIDAE	
Tympanuchus pallidinctus	Lesser prairie chicken
FAM. PHASIANIDAE	
Callipepla squamata	Scaled quail
Colinus virginianus	Bobwhite quail
Phasianus colchicus[1]	Ring-necked pheasant
FAM. ARDEIDAE	
Casmerodius albus	Great egret
Bubulcus ibis	Cattle egret
Ardea herodias[1]	Great blue heron
Florida caerulea	Little blue heron
Nycticorax nycticorax	Black-crowned night heron
FAM. THRESKIORNITHIDAE	
Plegadis chihi	White-faced ibis
FAM. GRUIDAE	
Grus americana	Whooping crane
Grus canadensis[1]	Sandhill crane
FAM. RALLIDAE	
Porzana carolina	Sora rail
Fulica americana	American coot
FAM. RECURVIROSTRIDAE	
Recurvirostra americana[1]	American avocet
Himantopus mexicanus	Black-necked stilt
FAM. CHARADRIIDAE	
Eupoda montana	Mountain plover
Charadrius alexandrinus	Snowy plover
C. vociferus[1]	Killdeer
FAM. SCOLOPACIDAE	
Numenius americanus	Long-billed curlew
Limosa fedoa	Marbled godwit
Bartramia longicauda	Upland sandpiper
Catoptrophorus semipalmatus	Willet
Totanus melanoleucus	Greater yellowlegs
Totanus flavipes	Lesser yellowlegs
Micropalama himantopus	Stilt sandpiper
Limnodromus scolopaceus	Long-billed dowitcher
Erolia sp.	Sandpiper

APPENDIX B (continued)

Scientific Name	Common Name
FAM. PHALAROPODIDAE	
Steganopus tricolor	Wilson's phalarope
Lobipes lobatus[1]	Northern phalarope
FAM. LARIDAE	
Larus pipixcan	Franklin's gull
SUB. FAM. STERNINAE	
Chlidonias niger	Black tern
FAM. COLUMBIDAE	
Zenaidura macroura[1]	Mourning dove
Columba livia	Rock dove (pigeon)
FAM. CUCULIDAE	
Coccyzus americanus	Yellow-billed cuckoo
Geococcyx californianus	Roadrunner
FAM. TYTONIDAE	
Tyto alba	Barn owl
FAM. STRIGIDAE	
Speotyto cunicularia[1]	Burrowing owl
Asio flammeus	Short-eared owl
FAM. CAPRIMULGIDAE	
Chordeiles minor	Common nighthawk
FAM. ALCEDINIDAE	
Megaceryle alcyon	Belted kingfisher
FAM. PICIDAE	
Asyndesmus lewis	Lewis' woodpecker
Dendrocopos pubescens	Downy woodpecker
FAM. TYRANNIDAE	
Muscivora forfic	Scissor-tailed flycatcher
Tyrannus tyrannus	Eastern kingbird
T. verticalis	Western kingbird
Myiarchus crinitus	Crested flycatcher
FAM. ALAUDIDAE	
Eremophila alpestris[1]	Horned lark
FAM. HIRUNDINIDAE	
Iridoprocne bicolor	Tree swallow
Hirundo rustica	Barn swallow

APPENDIX B (continued)

Scientific Name	Common Name
FAM. HIRUNDINIDAE (continued)	
Petrochelidon pyrrhonota	Cliff swallow
Tachycineta thalassina	Violet-green swallow
Stelgidopteryx ruficollis	Rough-winged swallow
Riparia riparia	Bank swallow
FAM. CORVIDAE	
Corvus corax	Common raven
C. cryptoleucus	White-necked raven
C. brachyrhynchos	Common crow
FAM. TROGLODYTIDAE	
Campylorhynchus brunneicapillus	Cactus wren
Salpinctes obsoletus	Rock wren
FAM. MIMIDAE	
Mimis polyglottos	Mockingbird
FAM. SYLVIIDAE	
Regulus calendula	Ruby-crowned kinglet
FAM. MOTACILLIDAE	
Anthus spinoletta	Water pipit
FAM. LANIIDAE	
Lanius ludovicianus	Loggerhead shrike
FAM. ICTERIDAE	
Sturnella neglecta[1]	Western meadowlark
Xanthocephalus xanthocephalus[1]	Yellow-headed blackbird
Agelaius phoeniceus[1]	Red-winged blackbird
Quiscalus quiscula	Common grackle
Molothrus ater	Brown-headed cowbird
Icterus galbula	Northern oriole
FAM. FRINGILLIDAE	
Richmondena cardinalis	Cardinal
Guiraca caerulea	Blue grosbeak
Carpodacus mexicanus	House finch
Passerculus sandwichensis	Savannah sparrow
Ammondramus savannarum	Grasshopper sparrow
Calamospiza melanocorys[1]	Lark bunting
Chondestes grammacus	Lark sparrow
Aimophila cassinii	Cassin's sparrow

APPENDIX B (concluded)

Scientific Name	Common Name
FAM. FRINGILLIDAE (continued)	
Spizella pusilla[1]	Field sparrow
Zonotrichia leucophrys	White-crowned sparrow

[1] Indicates most commonly noted

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APPENDIX C

Mammals of Playas and Associated Habitats in the Southern High Plains (Llano Estacado) Study Area of Curtis and Beierman (1980).

Scientific Name	Common Name
ORDER CHIROPTERA	
Antrozous pallidus	Pallid bat
ORDER CARNIVORA	
Procyon lotor[1]	Raccoon
Mephitis mephitis	Striped skunk
Taxidea taxus[1]	Badger
Urocyon cinereoargentus	Gray fox
Vulpes macrotis	Desert fox (kit)
Canis latrans[1]	Coyote
Felis concolor	Cougar
Lynx rufus	Bobcat
ORDER RODENTIA	
Spermophilus tridecemlineatus	Thirteen-lined ground squirrel
Cynomys ludovicianus[1]	Blacktail prairie dog
Geomys bursarius	Plains pocket gopher
Neotoma micropus	Gray wood rat
ORDER LAGOMORPHA	
Lepus californicus[1]	California jackrabbit
Sylvilagus floridanus[1]	Eastern cottontail
Sylvilagus auduboni[1]	Audubon cottontail
ORDER ARTIODACTYLA	
Antilocapra americana[1]	Pronghorn
Odocoileus hemionus	Mule deer

[1] Indicates most commonly noted

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APPENDIX D

Amphibians, Reptiles, and Fishes of Playas and Associated Habitats in the Southern High Plains (Llano Estacado) Study Area of Curtis and Beierman (1980).

Scientific Name	Common Name
FAM. CHELYDRIDAE	
Kinosternon flavescens	Yellow mud turtle
FAM. TESTUDINIDAE	
Terrapene ornata	Ornate box turtle
FAM. IGUANIDAE	
Phrynosoma cornutum	Texas horned lizard
FAM. COLUBRIDAE	
Thamnophis marcianus[1]	Checkered garter snake
Thamnophis sauritus proximus	Western ribbon snake
Coluber constrictor foxi	Blue racer
Opheodrys vernalis	Smooth green snake
FAM. VIPERIDAE	
Crotalus atrox	Diamondback rattlesnake
Crotalus viridis viridis	Prairie rattlesnake
FAM. AMBYSTOMIDAE	
Ambystoma tigrinum[1]	Eastern tiger salamander
FAM. PELOBATIDAE	
Scaphiopus sp.	Spadefoot toad
FAM. BUFONIDAE	
Bufo cognatus[1]	Great Plains toad
FAM. HYLIDAE	
Acris crepitans	Cricket frog
Pseudacris clarki	Spotted chorus frog
FAM. RANIDAE	
Rana catesbeiana[1]	Bullfrog
Rana pipiens	Leopard frog
FAM. CENTRARCHIDAE	
Lepomis macrochirus	Bluegill sunfish
Micropterus salmoides	Largemouth bass
FAM. ICTALURIDAE	
Ictalurus melas	Black bullhead
Ictalurus natalis	Yellow bullhead

APPENDIX D (concluded)

Scientific Name	Common Name
FAM. ICTALURIDAE (continued)	
Ictalurus furcatus	Blue catfish
Ictalurus punctatus	Channel catfish
FAM. CYPRINIDAE	
Notemigonus crysoleucas	Golden shiner
Cyprinus carpio	Carp
Hybognathus hankinsoni	Brassy minnow
Pimephales promelas	Fathead minnow

[1] Indicates most commonly noted

APPENDIX E

Invertebrates of Playas and Associated Habitats in the Southern High Plains (Llano Estacado) Study Area of Curtis and Beierman (1980).

Scientific Name	Common Name
CLASS MOLLUSCA	Snails
CLASS CRUSTACEA	
ORDER NOTOSTRACA	
Apus sp.	Tadpole shrimp
ORDER ISOPODA	Water sow bugs
ORDER ANOSTRACA	
Eubranchipus sp.	Fairy shrimp
CLASS HIRUNDINEA	Leeches
CLASS INSECTA	
ORDER HEMIPTERA	
FAM. NOTONECTIDAE	Backswimmers
FAM. BELOSTOMATIDAE	Giant waterbugs
FAM. GERRIDAE	Water striders
ORDER HETEROPTERA	
FAM. CORIXIDAE	Water boatmen
ORDER COLEOPTERA	
Hyrophilus sp.	Water scavenger beetle
ORDER EPHEMEROPTERA	Mayflies
ORDER ODONATA	Dragonflies
	Damselflies
ORDER MEGALOPTEPA	Hellgrammites
ORDER DIPTERA	Midges
	Flies
	Mosquitoes
ORDER HYMENOPTERA	Bees
	Ants
ORDER ORTHOPTERA	Grasshoppers
	Crickets
ORDER LEPIDOPTERA	
Peiris sp.	Cabbage butterflies
Damaus sp.	Monarch butterflies

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This characterization incorporates recent research findings in a synthesis of knowledge about the habitat values of playa wetlands to migratory and resident wildlife. Variables which may affect the value of playa wildlife habitat include watershed size and the water surface area and depth; type, height, density, and interspersion of vegetation, and the extent of emergent vegetation; land use, particularly grazing and cultivation; and the extent of modification, particularly excavating and diking. The Southern Great Plains playa wetland region encompasses parts of the Texas Panhandle, adjacent eastern New Mexico, the Oklahoma Panhandle, Southwestern Kansas and southeastern Colorado.

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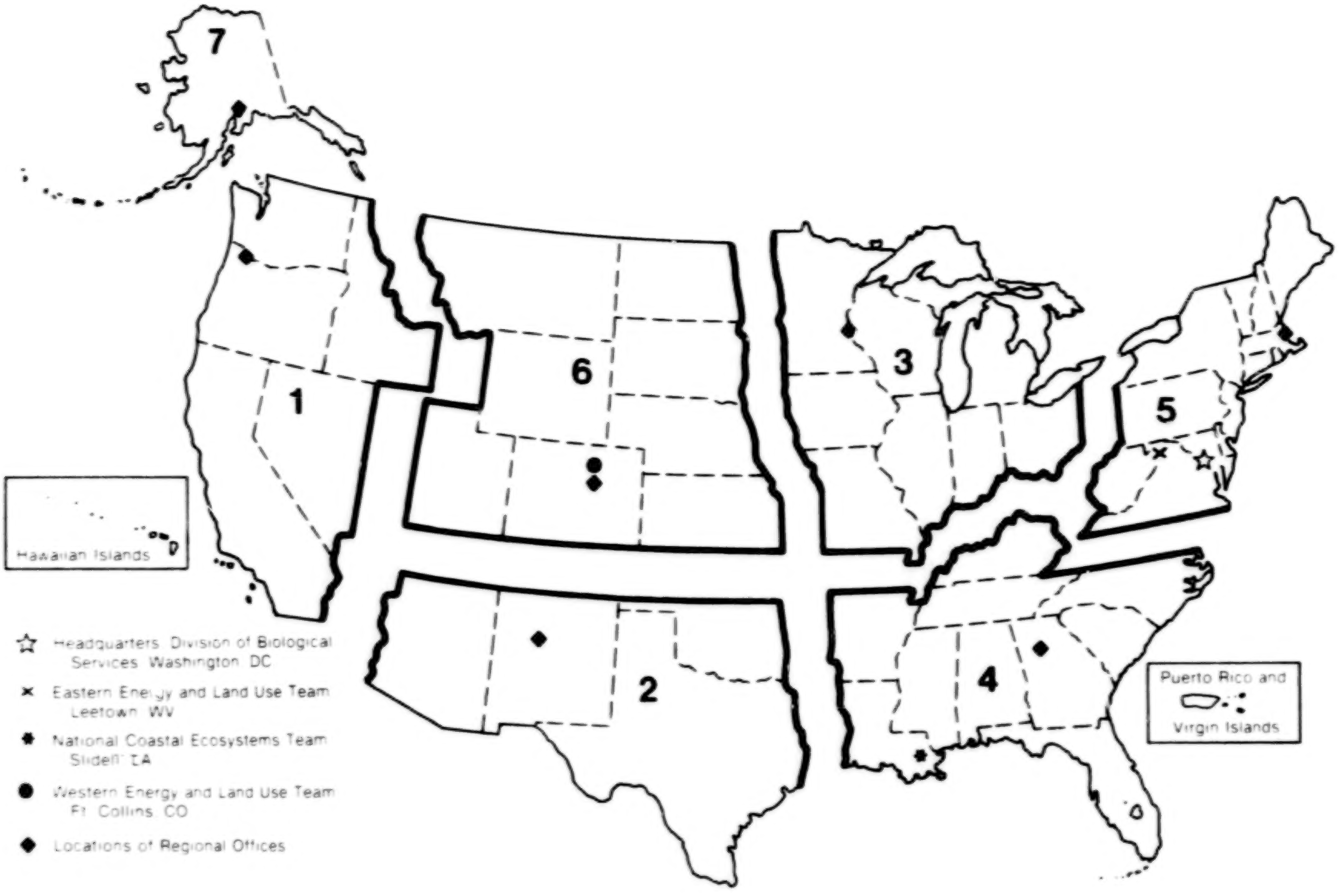
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